

UNIV. OF
TORONTO
LIBRARY

JAN. to DEC.,

1915.



10/6 Yearly.

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

1/- a Copy.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

VOL. VIII.

JAN. 1915 TO DEC. 1915

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,

32, VICTORIA STREET, LONDON, S.W.

(TEL. NO. VICTORIA 5215.)

TP

700

L54

v.8

VACHER AND SONS, LTD.,
WESTMINSTER HOUSE,
GREAT SMITH STREET,
LONDON, S.W.—48499.



Digitized by the Internet Archive
in 2010 with funding from
University of Toronto



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.

32, VICTORIA STREET, LONDON, S.W.

Tel. No. 5215 Victoria.

EDITORIAL.

Progress of the Past Year.

In the early part of 1914 a considerable amount of useful work was done by the Illuminating Engineering Society. In January the subject of daylight illumination, with special reference to school lighting, came up for discussion, and a very complete paper by Mr. P. J. Waldram was presented on this subject. At the same time a series of queries was addressed to a number of distinguished corresponding members of the Society in Europe and America, and the information received formed a most useful preliminary to further action. Subsequently a special sub-committee of the school-lighting committee was appointed to make further investigation and to report to the main Committee the results of their deliberations. The report was submitted to the Council and issued as the report on "The Natural Lighting of School Rooms," which was published in the July number of the ILLUMINATING ENGINEER. The Committee carried out a considerable number of investigations and tests in schools of various types, and the report received an exceptional amount of attention throughout the whole country, and particularly by the educational authorities and the press connected with these matters.

At the meeting following, a discussion on "The Lighting of Art Studios and Picture Galleries" was opened by Professor Silvanus Thompson, both natural and artificial lighting being considered. The previous work on daylight problems and the investigations carried out by members of the Society during 1913 on the subject of "Shadows by Artificial and Natural Light" provided a useful introduction to this paper.

Following this there were papers by Professor Clinton and Mr. A. P. Trotter. Professor Clinton's interesting and instructive contribution showed the practicability of working out beforehand the illumination to be derived from any given scheme of lighting, and subsequently verifying these results by actual measurements. Mr. Trotter dealt with the "Nomenclature of Photometric Quantities"—a matter of considerable importance from an international standpoint. Here again the assistance of corresponding members of the Society on the Continent and in America were found of great value. Among other features of the session we may note the discussion of the "Lighting of Railway Carriages and Public Vehicles," opened by Mr. E. Kilburn Scott.

THE LIGHTING OF LONDON.

A paper before the London Society on the Lighting of London was also read by the writer. In this paper data were provided showing the remarkable progress in the Lighting of London during the last thirty years, and a number of photographs, taken especially by artificial light, were presented.

The paper emphasised the great opportunities for developing the artistic side of public lighting and the illumination of the public parks. The writer also pointed out the great variety of authorities by whom the lighting of London is controlled, and the need for some central department for dealing with the technical and artistic aspects of the subject in a scientific co-ordinated manner. In view of the Bill now before Parliament regarding the proposed reorganisation of London's electricity supply, this point is of special interest. The London Society, it is hoped, will use its influence in carrying into effect some of the suggestions made in the paper. Among other events of interest in the early part of 1914 there remains to be mentioned the Annual Dinner, which was attended by a number of distinguished guests, and proved to be one of the most successful yet had; a gratifying feature was the presence in the chair of Sir William Bennett, K.C.V.O., F.R.C.S., the new President of the Society. The occasion was taken to put on record the Society's high appreciation of the services of Professor Silvanus Thompson, who occupied the Presidential Chair during the initial four years of the Society's existence.

THE OUTBREAK OF WAR.

When the session came to an end, therefore, everything pointed to an active resumption of work under favourable conditions in the autumn. The continued existence and prosperity of the Society in this country was assured. The Society in the United States and the newly formed Society

with similar aims in Germany were also actively carrying on the work; and in France and Belgium and other countries illuminating engineering was making steady progress. The international side of the movement had assumed definite shape, through the formation of the International Commission on Illumination, and in this country arrangements had been made for active steps to be taken with a view to extending the movement throughout the United Kingdom. The August issue (1914) of the ILLUMINATING ENGINEER contained a special summary of the work of the Society up to date, and was specially prepared with a view to increasing the membership of the Society and to extend its scope of operation.

Within a few weeks after the issue of that number many of those who had been establishing friendly relations became enemies. On the Continent, owing to the vast preparations for war, the movement is in abeyance. Even in this country many outlets for our activities have been checked. Many of those upon whose aid we had counted are now serving their country with the forces. Support confidently expected was for the time being inevitably diverted elsewhere, and it was at once evident that the proposed widespread effort to arouse interest in the movement would have to be postponed.

OPPORTUNITIES OF THE ILLUMINATING ENGINEERING MOVEMENT.

Nevertheless it was felt to be essential to maintain the continuity of the Society's work, and in spite of existing difficulties to "stand by our guns" and preserve the movement which has been so laboriously built up during the last few years. While the war has inevitably checked our work in some directions, it has provided opportunities of usefulness in others. One of the first results of hostilities was a considerable amount of dislocation of the lighting industry owing to the stoppage of Continental supplies. Immediately after the declaration of war inquiries were made among various firms interested in lamps and lighting appliances, and the results were published in the ILLUMINATING ENGINEER.*

FOSTERING THE MANUFACTURE OF LIGHTING MATERIALS AND APPLIANCES.

It was freely acknowledged that the withdrawal of Continental supplies had caused inconvenience.

It was, however, realised that the present inconvenience of not being able to import many needful things might lead to their being manufactured in this country. The unparalleled circumstances brought about by the present war present a unique opportunity to the lighting industry, and our investigations during the last few months have shown that there are many sections of the industry which are meeting the new conditions with commendable enterprise. But, as we have pointed out before, no industry worth capturing can be built up without long and sustained effort, careful organisation, and indomitable enterprise. In particular, it is essential to find out at an early stage which is practicable and what is not. It has, therefore, been suggested to the authorities in this country that committees,

* September and November, 1914.

composed of men with technical knowledge, should be formed in order to make a complete scientific survey of certain sections of business—such as the lighting industry—which deal with absolute national necessities. We are hopeful that the efforts being made in this direction will lead to useful results. In passing, we would like to say that the illuminating engineering movement has every reason to be satisfied with the friendly attitude by authorities in this country towards its aims and objects.

THE LIGHTING IN LONDON IN WAR TIME.

Another matter which has certainly affected the lighting industry deeply is the regulations imposed by the authorities for the darkening of the streets and the restrictions on shop lighting. Recognising the immediate importance of these conditions, the Society took up the matter at its opening meeting in the present session on December 1st, which is reported in our present number (see pp. 11-26). At this meeting the question of show window lighting received special attention.

We are all of us willing to accept loyally any regulations made in the interests of the defence of the Realm. On the other hand, it must of course be recognised that such measures, however necessary for safety, do have a restriction on business as well as being prejudicial to the lighting industry, and the Council of the Society is now suggesting some more specific recommendations on window lighting with a view to securing compliance with the regulations and, at the same time, getting the most satisfactory illumination.

A RECORD OF THE PRESENT LIGHTING CONDITIONS NEEDED.

Circumstances have provided us with an opportunity of seeing some experiments in street lighting which would never have been tried in ordinary times, and it ought to be possible to extract some useful lessons from the results. Permission has already been obtained from the authorities to take a series of photographs and measurements of illumination in the streets of London, so as to form a record of the present conditions. It would be of the greatest value to have also an analysis of the effect of the new conditions on traffic and to trace as closely as possible the relation between diminished illumination and the number of accidents in the streets.

Finally, we may conclude by asserting our conviction that the present time with its changing conditions in public illumination and reconstructions in the fabric of the lighting industry, make the existence of the illuminating engineering movement of even greater value than in ordinary circumstances, and we hope that all supporters will help us with greater determination and increased vigour to keep the work alive.

Before completing this short review we take the opportunity of thanking the technical daily press for the greater attention they constantly pay to the value of good lighting and the recognition given to the good work of the Society.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(A Report presented by the Committee on Progress at the Eighth Annual Convention of the Illuminating Engineering Society (U.S.A.), at Cleveland, Sept. 21-24, 1914; slightly abbreviated.)

(Continued from page 552 in Vol. VII.)

Street Lighting.

The constant demand for better public lighting is reflected in the increase in installations in some of the large cities of the country, during the past year. The luminous arc was being installed in large numbers up to the time of the introduction of the non-vacuum high efficiency tungsten lamp. There is already considerable evidence that the latter will be used in many places to replace the former.

Portland, Ore.—In Portland, Oregon, there has been an increase of 300 in the number of arc lamps with a decrease in rates of 7.8 per cent. for overhead arcs and 15.2 per cent. for underground. On one street ten blocks of display lighting has been installed consisting of arches at street intersections having a 1,000-watt lamp in the centre, and 48 40-watt lamps in each arm of the arch.

Seattle, Wash.—Seattle claims to be the first city to try out the new non-vacuum lamps for street lighting.⁶¹

Los Angeles, Cal.—The constant growth in the use of automobiles has increased the demand for well-lighted roads outside as well as inside the city. A large

boulevard system within fifteen miles of Los Angeles has been equipped with 375 tungsten standards,⁶² and 600 will be required to complete the system.

Denver, Colo.—In Denver 100 new metallic flaming arc lamps have been put in, as well as 100 enclosed carbon arcs, while in one street ornamental lighting has been installed to the extent of 102 standards carrying four 40-watt tungsten lamps each.

New Orleans, La.—New Orleans has increased the number of arc lamps used by 52 and installed 92 standards each equipped with a 200-candle-power series tungsten.

Galveston, Tex.—Galveston has installed 60 inverted arcs⁶³ on standards six to the block.

Milwaukee, Wis.—In Milwaukee 200 inverted flaming arcs have been added,⁶⁴ rated at 3,500 candle-power and spaced 50 to 60 feet (15.24 to 18.29 m.) apart. In addition an ordinance has been passed authorizing a study of street lighting systems⁶⁵ to determine the one best suited to the needs of the city.

⁶² *Elec. World*, December 6, 1913, p. 1165.

⁶³ *Lt. Jour.* (U.S.), May, 1914, p. 108.

⁶⁴ *Elec. World*, January 24, 1914, p. 210.

⁶⁵ *Elec. World*, June 27, 1914, p. 1480.

⁶¹ *Elec. World*, January 10, 1914, p. 98.

Minneapolis, Minn.—Minneapolis has increased the number of magnetite arcs from 2,400 to 2,800⁶⁶ while the rate has decreased 4 per cent. One hundred gas lamps have been dropped.

Chicago, Ill.—The following table shows the progress in Chicago:—

	June 1, 1913.	June 1, 1914.
Arc lamps	17,084	18,973
80-watt tungsten lamps	814	4,433
Gas lamps	12,714	11,761
Gasoline lamps ..	7,845	5,120
25-watt subway lamps..	302	4,409

Arrangements were completed, except for hanging, for the installation of 3,839 flaming arc lamps, but a trial installation of 2,000 of the new non-vacuum high efficiency tungsten lamps, 300-watt size, has replaced part of these. The cost of arc lamps not municipally lighted has remained the same. The cost of those under municipal operation (depreciation and investment charges allowed for) has decreased 6·7 per cent. The municipally operated tungsten lamps decreased in cost 12·4 per cent. The cost of gas lamps dropped 2·8 per cent., while gasoline lamps operated under contract were renewed at a decrease in contract price of 3 per cent. per lamp.

The latest development (June 19, 1914) has been a decision to replace 1,000 direct-current open arcs and 6,000 7-ampère carbon arcs with the new tungsten units.

Detroit, Mich.—Progress in Detroit⁶⁷ is indicated by the addition of 240 4-ampère arcs on underground circuits and 575 of the same lamps on overhead circuits, as well as 100 inverted magnetite arcs at intervals of 159 feet (48·47 m.) measured centre to centre.

Washington, D.C.—At Washington, D.C. a number of series enclosed arc lamps have been replaced by the 6·6-ampère luminous arcs, the latter being mounted on standards especially designed for the purpose. But on the other hand 946 arc lamps of various types have been replaced by 1,573 125-candle-power incandescent lamps and 206 80-candle-power lamps all on underground circuits. The number of gas lamps, 60-candle-power mantle type is 10,246 with a gradual yearly increase.

Philadelphia, Pa.—In Philadelphia the number of arc lamp used increased from 14,421 to 14,425 while there is a regular yearly increase of 300 in the number of gas lamps. The latter are provided free. The cost of arc lamps decreased 5 per cent. per lamp. Gasoline lamps remained unchanged in number and price per lamp.

New York, N.Y.—New York City has increased the number of arcs from 19,430 to 19,634 the rates remaining the same except in the case of the 475-watt single flaming arcs where there was a decrease in price of 4 per cent. The number of incandescent lamps changed from 18,734 to 21,185 the rates remaining practically the same. Provision has been made to change the series incandescent lamps to the new non-vacuum lamps of 70-watt size.

Worcester, Mass.—Worcester, Mass., has installed 500 6·6-ampère luminous arc lamps⁶⁸ at distances of from 80 to 125 feet. (24·38 to 38·1 m.)

Boston, Mass.—In Boston⁶⁹ there has been a reduction of 14·8 per cent. in the cost of arcs, while Brookline⁷⁰ has made a beginning towards improved illumination by installing 45 luminous arc lamps.

France.—Abroad gas lighting maintains its popularity as a street illuminant.⁷¹ In Paris in particular high pressure lighting has been making considerable gains as may be seen from the following table:—

NUMBER OF LAMPS.

Year	500 c.p.	1,000 c.p.	2,000 c.p.	4,000 c.p.	Total
1910 ..	—	7	68	29	104
1911 ..	—	7	305	68	380
1912 ..	—	33	315	117	470
1913 ..	16	193	875	159	1,243

Great Britain.—High pressure gas lighting has also made gains⁷² in England, and at Edinburgh, Scotland, an experimental installation of 16 lamps has been made. These have replaced 36 of the ordinary type. They are lighted and extinguished automatically and several have been provided with two burners, one of which is extinguished at midnight.

⁶⁸ *Elec. World*, June 27, 1914, p. 1482.

⁶⁹ *Elec. World*, March 25, 1914, p. 685.

⁷⁰ *Elec. Rev. & W.E.*, November 27, 1913, p. 1010.

⁷¹ *Jour. Gas Lt.*, June 16, 1914, p. 776.

⁷² *Jour. Gas Lt.*, October 14, 1913, p. 140.

⁶⁶ *Elec. World*, January 24, 1914, p. 196.

⁶⁷ *Elec. World*, January 24, 1914, p. 212.

At Leeds, England,⁷³ the high pressure system is to be extended. Glasgow has been extremely progressive on the street lighting question,⁷⁴ and there has been since 1895 an increase in the number of gas lamps from 13,672 to 106,684 while electric lamps have been introduced to the number of 5,116. An interesting development in Glasgow,⁷⁵ has been the taking over by the municipality of the lighting of those private streets, closes, stairs, etc., which have been taken care of by private interests since 1866.

In London, 430 arc lamps have recently been added to the square mile embraced in the original city.⁷⁶ A distinctive feature of the globes is the inclusion of a dioptric lens to aid in the distribution of the light horizontally and downward.

Italy.—A pretentious program has been started in Turin, Italy,⁷⁷ where over \$500,000 have been appropriated for improved lighting. For the main streets approximately 3,000 flaming arcs are to be provided, while the side streets will be lighted by incandescent lamps.

Specifications.—The question of street lighting specifications has been a prolific source of argument and difference of opinion for some years. A recent extended discussion in England⁷⁸ served only to emphasize the lack of unanimity on the part of lighting engineers as to just what the requirements are for satisfactory street illumination. The problem has been attacked in this country⁷⁹ by a committee appointed by the National Electric Light Association and the Association of Edison Illuminating Companies along lines somewhat different from those previously employed. It was assumed that the fundamental purposes to be served by street illumination are:—

1. Discernment of large objects in the street and on the sidewalk.

2. Discernment of surface irregularities in the street and on the sidewalk.

3. Good general appearance of the lighted street.

Two actual streets were equipped for observation under working conditions and comparative tests have been developed to determine in these streets which of two streets lighting systems serves each of the above-mentioned purposes the better. In the past, tests of street lighting have been confined almost exclusively to photometric measurements either on horizontal or vertical planes or both. In the tests in question, observation was made the principal point of comparison, but complete photometric data were also obtained comprising the candle-power of the illuminants and measurements of the horizontal and vertical illumination and of brightness. Eight series of observational tests were made using as many as twelve observers who both riding and walking recorded their judgment on such questions as ability to see the faces of people met on the sidewalk, irregularities in the pavement, obstructions in the roadway, ability to read print, tell time, etc. The final results have not yet been obtained.

Public interest.—That the public is beginning to recognize the desirability of good lighting is indicated by the recent action of a club,⁸⁰ in one of the large cities, which appointed a committee to investigate the question of street lighting and make recommendations to the city council.

In another city a "Municipal Lighting Day" was held at the State University⁸¹ for the benefit of city officials throughout the State and for others interested in the conduct of municipal affairs. This included lectures and demonstrations on the subject of street lighting.

Exterior Illumination.

The satisfactory results obtained in the artificial lighting of tennis courts has caused a considerable extension of this form of lighting. In England⁸² covered tennis and squash courts have been artificially lighted, both with high pressure gas units and electric lamps.

⁷³ *Jour. Gas Lt.*, October 14, 1913, p. 169.

⁷⁴ *Lt. Jour.* (London), May, 1914, p. 230.

⁷⁵ *Ill. Eng.*, (London), May, 1914, p. 228.

⁷⁶ *Elec. Rev. & W.E.*, July 28, 1914, p. 131.

⁷⁷ *L'Electricien*, March 28, 1914, p. 203.

⁷⁸ *Elec.*, May 8, 1914, p. 179.

⁷⁹ Report Committee on Street Lighting—National Electric Light Association, June, 1914.

⁸⁰ *Elec. World*, January 31, 1914, p. 368.

⁸¹ *Elec. Rev. & W.E.*, February 14, 1914, p. 339.

⁸² *Elec. Eng.* (London), February 19, 1914, p. 101.

The value of light seems to be more and more appreciated in every walk of life. An experiment in the use of artificial light to increase the output of a poultry farm⁸³ has resulted in a reported increase of 30 to 40 per cent. in the number of eggs laid. In the case of young incubated chicks, the use of light made them feed longer and thereby accelerated their growth during the winter months by a third.

The growth of aeronautics has created the need of properly illuminated fields for rising and descending at night,⁸⁴ and various suggestions have been made and experiments tried to determine the most suitable method. A need has also arisen for illuminated signals and signs so that an aeronaut travelling at night may determine his location and avoid dangers in descending. In the case of signal lights on the machine themselves, it is evident that arrangements must be made to indicate not only the direction of travel in a single plane but also whether a rise or drop is contemplated.

It is interesting to note that the Port of London Authority has recently equipped the dock policemen with electric torches⁸⁵ to take the place of the old-fashioned oil lanterns.

The logical development of the animated sign⁸⁶ has made its appearance in the use of moving vehicles carrying highly illuminated displays.

The lighting of Christmas trees in the home⁸⁷ is a custom almost if not quite as old as the use of the tree itself. A recent innovation adopted by many American cities at the last holiday season consisted of out-door "community" trees, in all of which illumination was a conspicuous feature of the ornamentation.

In regard to display lighting in general there has been a decided increase in the number of buildings lighted on the exterior for display purposes. In the past there have been numerous cases of so-called "outline" lighting, in which the lights showed the contours. A new method called "flood" lighting is being introduced in which the exterior of the

building is brilliantly illuminated by sources placed at a distance.

The use of high towers for street illumination purposes was discontinued some years ago. The system has been revived recently for use in lighting railroad yards.⁸⁸ Steel towers 100 ft. (30.48 m.) high and 12 ft. square (3.66 m.) at the base have been placed at 500 ft. (152.40 m.) intervals and equipped with quartz mercury-vapour arc lamps.

Interior Illumination.

Car Lighting.—Interest in improving the lighting of railway coaches and street cars continues⁸⁹ and is apparently growing. Indirect and semi-indirect methods are being studied. In one city twenty street cars have been equipped with three different semi-indirect systems in order to see which appeals most strongly to the public. There is a general recognition that bare lamps are bad and that it is well worth while to use reflectors.

The final report of the Committee on Illumination of the Association of Railway Electrical Engineers⁹⁰ contains among other conclusions that equally satisfactory results may be obtained with either the centre deck or half deck arrangement of the lighting units; best results will be obtained with a spacing not greater than two seats apart. The elaborateness of the tests and the expense involved are a most gratifying tribute to the importance attached to better lighting in trains.

Store Lighting.—That the educational efforts of this society⁹¹ are continuing to bear fruit is indicated in the lighting installation of a large department store. In this case the window lighting system was worked out with foot lamps and border lamps equipped with movable colour screens, so that the quality of the light could be altered to suit the requirements. The main lighting, of the semi-indirect type, has also a modified colour value. For the trying on of theatrical costumes, the foot lamps and border

⁸⁸ *Elec. World*, July 11, 1914, p. 85.

⁸⁹ *Trans. I.E.S.*, January, 1914, p. 25; *Rlwy. Elec. Eng.*, November, 1913, p. 249, and December, 1913, p. 264.

⁹⁰ *Report of Comm. on Illumination of Assoc. Rlwy. Elec. Eng.*, 1914.

⁹¹ *Elec. World*, May 24, 1914, p. 1134.

⁸³ *Elec. World*, December 27, 1913, p. 1330.

⁸⁴ *Licht u Lampe*, October 23, 1913, p. 838.

⁸⁵ *Ill. Eng.* (London), February, 1914, p. 70.

⁸⁶ *Elec. Rev. & W.E.*, April 4, 1914, p. 656.

⁸⁷ *Elec. World*, January 3, 1914, p. 28.

lamps are not only provided with means for colour modification, but also with dimmers and a spot light is likewise available.

In order to eliminate the annoying reflections from the glass of show windows, a new system has been devised in which the window pane is made concave inward.⁹²

Another novel application of the indirect lighting system has been made in the case of banks⁹³ where the lamps are contained in troughs along the bank rail over the teller's desks.

School Lighting.—During the course of an extended discussion before the British Illuminating Engineering Society⁹⁴ on the subject of daylight illumination in schools, it was brought out that as a minimum actual illumination on the desk for reading in the schoolroom in full (mid-day) daylight, different authorities recommend from approximately 1 to 8 foot-candles. Among the new suggestions were, the determination of the "sill-ratio," *i.e.*, the ratio between the illumination on the window sill of the schoolroom and that on the desk most remote from the window, as a means of determining the access of daylight into schools; experiments to ascertain how far it is possible by using small models to predict the actual daylight conditions in an interior; and an "indicator-photometer" as a means of signalling when the artificial light should be turned on.

In a later⁹⁵ interim report the following tentative suggestions were made:—

"No place is fit for use in a schoolroom when 'diamond type' cannot be read easily by a normal observer at a distance of half a meter.

"The darkest desk in any schoolroom should receive an illumination equivalent to that derived directly from 50 reduced square degrees of visible sky. In these circumstances the place should receive not less than 0.5 per cent. of the unrestricted illumination from the complete sky hemisphere.

"The windows should be located in the wall to the left of the pupils, and the glass should be carried to the ceiling and

not interrupted by cornice, pillars, or decorations.

"No desk in a schoolroom should be farther from the window wall than twice the height of the top of the glass above the desk surface.

"The ceiling should be white. The wall opposite to the window and the wall behind the children should be lightly coloured from 30 in. (0.76 m.) above the desk level. The wall around or behind blackboards should be somewhat darker than the rest of the room.

"All furniture, desks, and surfaces in the lower part of the room should be finished in an unobtrusive colour, dark shades and black being avoided."

It should be noted that there are some points in these suggestions on which more definite information is desirable, and further work on the subject will doubtless meet this need.

Church Lighting.—There is a growing tendency away from the old belief that the interior of a church should be in a state of twilight illumination,⁹⁶ toward a realization that the church should be made cheerful and that this is to be accomplished by good lighting. For this purpose the indirect lighting method is growing in favour although the lower installation and operating costs, as well as the architects' influence, are responsible for the use of direct lighting in some cases even in new churches.

Picture Lighting.—The proper lighting of pictures has been a vexing problem with illuminating engineers for many years. While it is comparatively easy to see what is required for a single picture, to produce the result not only for one, but many, has taxed the resources of numerous engineers and architects. At a recent Art Loan Exhibition an effort was made⁹⁷ to illuminate the pictures as far as possible by light coming from the right direction and also of the proper colour content. Plain and coloured lamps were used, placed in troughs above and in front of the frames and so arranged that no light was specularly reflected to the eye of the observer.

(To be continued.)

⁹² *Tech. World*, July, 1914, p. 686.

⁹³ *Ill. Eng.* (London), January, 1914, p. 8.

⁹⁴ *Ill. Eng.* (London), January, 1914, p. 15.

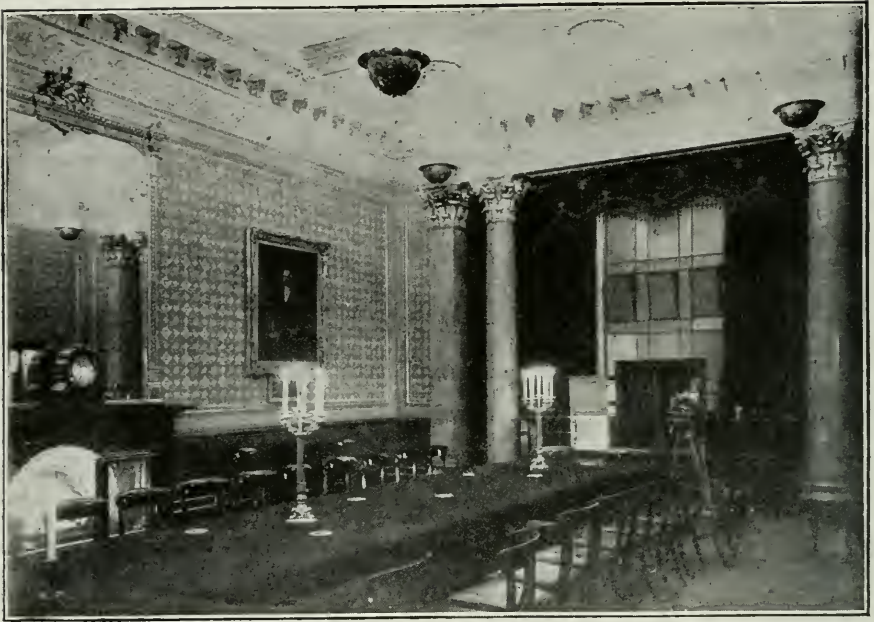
⁹⁵ *Ill. Eng.* (London), July, 1914, p. 365.

⁹⁶ *Elec. Rev. & W.E.*, November 1, 1913, p. 856.

⁹⁷ *Elec. Rev. & W.E.*, December, 13, 1913, p. 1127.

THE LIGHTING OF A FAMOUS HALL.

The Dyer's Hall, Dowgate Hill, London, E.C.



Lumina Bureau Photo.

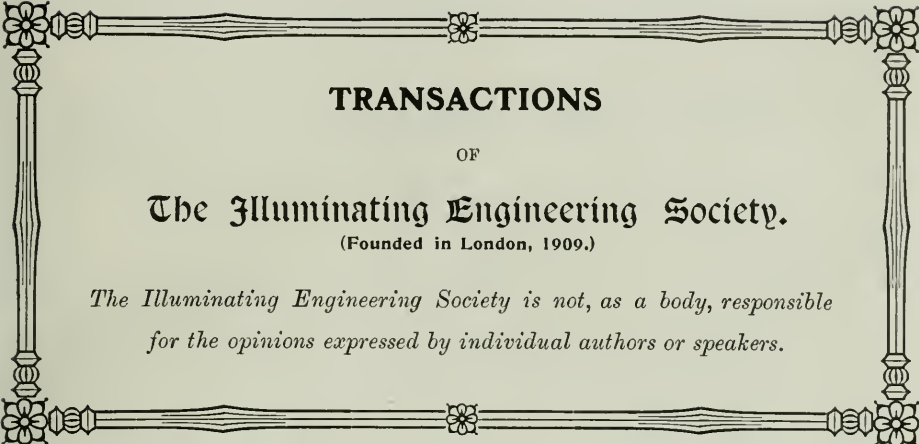
THE lighting of this historic hall is remarkable in several respects. People sometimes speak as though all halls should be lighted on substantially the same principles; for instance, general lighting of moderate intensity over the auditorium, supplemented by stronger illumination by well shaded lights on the platform.

This dictum may apply to halls used for public meetings. But there are many halls belonging to guilds and corporations where historic associations have a controlling influence. The Dyer's Hall is used for Council meetings and occasionally for banquets, and is probably one of the most beautifully proportioned and decorated halls in the City of London.

The ceiling is unique, and the cost of the original design, involving much costly gilding, is said to have been extremely high.

The lighting has accordingly been designed to suit the interior, and in particular to show off the ceiling. Indirect lighting is used, the lamps being concealed in hanging copper dishes. Judging by modern standard the illumination is not strong; with the candles unlighted it does not exceed half a foot-candle.

Owing, however, to the complete absence of glare, and the subtle influence of the surroundings, this subdued lighting does not seem distasteful, and the lighted candles give just that extra stimulus that is needed to avoid a tendency to depression.



TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ILLUMINATING ENGINEERING IN WAR TIME.

Some Lessons to be learned from the present Lighting of London.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, December 1st, 1914.)

THE opening meeting of the Session was held as stated above, Mr. F. W. GOODENOUGH being in the chair.

The minutes of the last meeting having been taken as read, the HON. SECRETARY announced the names of members in the usual way, alluding to the acceptance on the part of Sir CORBET WOODALL, D.Sc., M.Inst.C.E., of Honorary Membership in the Society. The Council has also nominated Mr. Thomas Alva Edison an Hon. Member in recognition of his distinguished services as one of the inventors of the incandescent electric lamp.

The CHAIRMAN then called upon Mr. Leon Gaster to open the discussion on "Illuminating Engineering in War Time." In the subsequent discussion the CHAIRMAN, Mr. J. W. T. WALSH, Mr. F. BAILEY, Mr. W. J. LIBERTY, Mr. T. E. RITCHIE, Mr. A. CUNNINGTON, Mr. F. W. WILLCOX, Mr. MACINTYRE, Mr. C. BUSSELL, Mr. F. C. TILLEY took part, and Mr. L. GASTER briefly replied to the various points raised.

In conclusion, the CHAIRMAN announced that the next meeting would be held on January 19th, when a discussion on Searchlights would take place.

NEW MEMBERS OF THE SOCIETY.

THE names of applicants for membership announced at the Annual Meeting on May 21st, 1914, were read again, and these gentlemen were formally declared members of the Society.*

In addition, the names of the following applicants have been duly submitted and approved by the Council, and were also read :—

Hon. Members :—

Woodall, Sir Corbet, <i>D.Sc., M.Inst.C.E.</i>	Governor of the Gas Light and Coke Co., Honorary Councillor and Past-President of the Institution of Gas Engineers, Palace Chambers, Bridge Street, WESTMINSTER, S.W.
---	---

Ordinary Members :—

Ball, R.	Director of Messrs. Julius Sax & Co., 24A, High Street, LONDON, W.C. (2).
Callow, S. H.	Messrs. Siemens Bros. Dynamo Works, Ltd., Tyssen Street, Dalston, LONDON (3).
Louis, Prof. D. A.	123, Pall Mall, LONDON, S.W.
Pinkney, W. F. T.	Chief Engineer, Lighting Dept., Electric Supply Co., NEWCASTLE-ON-TYNE (3).
Podmore, A. E.	Gas Lighting Engineer, 34, Charles Street, Hatton Garden, LONDON, E.C. (2).
Russell, W. R. M.	Secretary and General Manager, Holophane, Ltd., 1, Trevor Square, Knightsbridge, LONDON, S.W. (2).
Sexton, F. P.	Consulting and Electrical Contracting Engineer to the Tamesco Co., Warwick Lodge, Hampton Wick, KINGSTON-ON-THAMES (2).
Turnham, A. E.	Elec. Contracting Engineer and Lighting Specialist, 12, John Street, Adelphi, LONDON, W. (2).
Widdows, G. H., <i>A.R.I.B.A.</i>	Architect and Surveyor, Derbyshire Education Committee, County Education Office, DERBY (3).

* *Illum. Eng.*, June 1914, p. 316.

RATING OF LAMPS IN LUMENS.

AT a recent meeting of the Committee of Nomenclature and Standards of the Illuminating Engineering Society (U.S.A.), the following resolution was adopted :—

Resolved, that it is the opinion of this Committee—

(A) That the output of all illuminants should be expressed in lumens ;

(B) That illuminants should be rated

upon a lumen basis instead of a candle-power basis ;

(c) That the specific output of electric lamps should be stated in lumens per watt, and the specific output of illuminants dependent upon combustion should be stated in lumens per British thermal unit per hour.

The resolution was approved by the Council of the Society, December 10th, 1914.

ILLUMINATING ENGINEERING IN WAR TIME.

Some Lessons to be learned from the present Lighting of London.

BY LEON GASTER.

Introduction to Discussion at the Meeting of Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m., on Tuesday, December 1st, 1914.

INTRODUCTION.

WHEN the members of this Society last met together in May, few of us imagined that before the new session had commenced this country would be plunged into the greatest war it has ever had to wage. By those of us who have aimed at the consolidation of international relations the devastating effect of war is particularly keenly felt. Only last year we were congratulating ourselves on the successful formation of the International Commission on Illumination, and looking forward to other forms of co-operation in the near future. Now much of this work must be laid aside, and we can only wait in patience for the time when the shadow has passed away, and it is possible once more to renew these relations.

It goes without saying that the war is having, and will have, a profound effect on the lighting industry, and my object in introducing this discussion is to point out how some aspects for the present situation affects the Illuminating Engineering Movement, and to consider what service the Illuminating Engineering Society can render to the lighting industry and the nation at the present time.

A number of members of the Society are present in the Regular Armies and the Territorial Forces, various others are actively engaged in the supply of material of apparatus required in the war. In battle to-day light plays a conspicuous part. I would suggest that when the war is over an account of the part played by illumination at the front would be of great interest to this Society. At the present moment it is better perhaps not to discuss these matters in detail. We know, however, that searchlights are

being widely used on land, at sea, and in the air. Flare lights are being used to enable the troops to dig trenches by night, and various forms of portable illuminants (acetylene, oil, &c.) have been employed in connection with transport and hospital work. Besides aiding the work of destruction, light has also been the means of preserving life, in facilitating the search for the wounded, and in making possible operations in the hospital tent which could never have been carried out by the primitive lighting arrangements used in campaigns in times gone by. As a Society we are familiar with the latest developments and applications of all illuminants, and it is probable that the expert advice of many of our members is being utilised in many directions at the present moment.

ILLUMINATION IN CAMP.

The use of light in connection with medical work and the Army Service Corps is well recognised. A particular problem in which the authorities must now be confronted is the lighting of many camps and barracks which are springing up all over the country to house Lord Kitchener's Army. During the past months the problems were not so heavy, as the nights were comparatively short. But during the winter light must be provided to enable the men to enjoy reasonable recreation when the day's work is over. I believe that several members of our Society have been concerned in work of this kind, and it is obvious that the lighting of these large areas in remote districts is quite a special problem.

This matter was recently commented upon in the *Sanitary Record*.* The

* Nov. 13, 1914.

writer pointed out the inadequacy of general rules, such as the provision of a certain candlepower per foot of floor space. It would be better to make provision for a certain illumination according to the use to which the interior is to be put.

LIGHTING OF RIFLE RANGES.

Another important question for the military authorities to consider is the lighting of rifle ranges. Not only in the new armies but in connection with the Volunteer associations this is worth studying.

During the winter it would be useful to be able to practice by night, so as to enable the troops to be out in the open during the short daytime. As for the Volunteer associations, their members for the most part are only free in the evening. Several installations of this kind have been recently described in the *ILLUMINATING ENGINEER*.^{*} The most essential point is the illumination of the targets *evenly* and by means of lights concealed from view, so that there is nothing to distract the eyes of the firing party.

Possibly the above remarks will lead to some members giving an account of their experiences in this direction.

Turning next to the general effect of the war on the lighting industry. Shortly after the commencement of the war the views of a number of gentlemen representative of the industry were invited and published in the *ILLUMINATING ENGINEER*. The general impression seems to be that the industry as a whole has not suffered as much as might have been expected. The demand for what may be termed the "luxury" branches of lighting has fallen, but in some instances this has been counterbalanced to some extent by extra requirements of a military kind.

The question of the maintenance of supplies of necessary materials in the lighting industry, some of which have been hitherto received from Germany or Austria, requires a very exhaustive inquiry. In order to make a complete survey of the situation, it is neces-

sary not merely to examine the present position but to consider the future possibilities in the event of the war lasting a considerable time. I may mention that representations have been made to the proper authorities with a view to avoiding any possible shortage.

LIGHTING OF LONDON'S STREETS IN WAR TIME.

The unusual lighting conditions prevailing in London and in various other localities have naturally been much discussed. These conditions are generally understood to be imposed as a precaution against possible raids from hostile aircraft, and naturally we as a Society must loyally accept the measures which are imposed for our safety. In what follows I do not propose to discuss their object or effectiveness for the purpose in view, but merely the actual lighting problems that have arisen: to see whether we cannot draw some useful conclusions from the very unusual experience of the last few months. Furthermore, while accepting the regulations made, it may be useful to consider the best methods, from an illuminating engineering standpoint, of meeting these requirements.

In considering these measures one would also have to bear in mind how far they are dictated by the desire to economise gas, electricity, or lighting materials (mantles, carbons, &c.), and how far they are designed as a measure of defence.

The most obvious change has been the alteration in the lighting of the streets, which applies also to goods yards, railway stations, and other large illuminated areas visible from above.

In some cases the authorities have contented themselves with simply turning out the majority of the lights, in others special forms of lamps have been installed; *e.g.*, in some streets the flame arc lamps have been replaced by glow lamps with opaque shades, completely screening the lights and directing the illumination on the roadway.

The methods practised are broadly divisible into two classes: (A) diminishing the power and the number of the lamps; (B) covering the lamp-globes with obscuring bands so as to block out the

^{*} September, p. 459; November, p. 522.

rays above and restrict the illumination below. It is obvious that various combinations of these methods might be used to give the same result, as far as the essential object of the changes is concerned, but might, at the same time, be widely different in their results from the illuminating engineering standpoint. For example, the width of the obscuring band has a very material effect on the illumination of the roadway; to the uninitiated it would appear that in some cases the amount of obscuration is unduly high and the merging cone of light very restricted; also that the area illuminated is very much less in some cases than in others. Naturally the practice in this respect may be expected to vary, according to the importance of the locality and the nature of the street.

I wonder whether any member of the Society has had the curiosity to attempt to measure the illumination in some of the main streets in the dark areas between the lamps: it must be exceedingly low in comparison with that prevailing in normal times. It would be a pity if the opportunity were not utilised to take a record of these highly unusual lighting conditions, and I have recently applied for and been granted a permit to take an extensive series of measurements and photographs. Without such a permit, experience shows, it would not be desirable to attempt the feat at the present time.

According to the most recent regulations, permission may be given to turn on the lights to their normal value in case of a fog. As matters stand, it would hardly be possible to do so in many cases, owing to the obscuring of the lamp-globes; this points to the desirability of having alternative methods of lighting—*e.g.*, some lamps unscreened, which are unlighted under ordinary conditions but could be turned on in a fog; or small candle-power glow-lamps as adjuncts to the arc lights and used instead of them (as is done even under normal conditions in some streets late at night).

I can recall several cases of streets lighted by incandescent electric lamps, a considerable proportion of which have been completely removed. Needless to say, in case of fog there would be some trouble in bringing the light back to its

normal condition, since it would be necessary to send round men to replace the lamps that have been taken away.

Speaking generally, the chief point of interest to the lighting engineer is "How far is it necessary to diminish the total amount of light, and how far is it possible to meet the required conditions merely by redirecting the rays?" Public safety, of course, comes first. But granted this, the minimum inconvenience would naturally be caused by the latter method. An observation of the present conditions leads one to suppose that it might be possible, without detriment to the authorities' wishes, to aim at greater uniformity of illumination, at least in the less important streets, and less "spottiness." Besides specific regulations as to the number of lamps to be turned on in certain streets, it might be useful to specify that the unobscured rays should be included within a certain prescribed maximum angle. The greater the permissible angle the less, of course, the inevitable spottiness.

It will be remembered that at the discussion of Mr. Trotter's Paper on the Street Lighting Specification last year the relative advantages of a uniform moderate illumination and an arrangement providing for brighter illumination at certain points, with lower values in between, was discussed. Now we have before us an example of conditions which would never be encountered in normal times—namely, very patchy lighting with an exceedingly low minimum. What conclusions can we draw from our experience? I think it will be generally agreed that the extreme contrast between the comparatively brightly lighted regions and those in obscurity is a drawback, particularly as regards guidance of traffic, and that our present experience confirms the desirability of fairly even illumination.

BRIGHT LIGHTING ATTRACTS CUSTOM.

However, taking the conditions as they are, what is the effect of the diminished lighting? There is now a state of things in the streets of London such as probably has not existed in the last fifty years, and which we may trust, we shall never see again. It would, therefore, be worth while to keep a record of their influence on the public mind and on the transaction

of business generally. Naturally, the matter has been considerably debated in the Press. One finds a fairly general impression that the absence of light has a certain depressing effect, that it tends to keep people indoors at night, thus checking the patronage of entertainments and evening shopping.

In some American cities statistics have been obtained purporting to show that light attracts crowds, and that the most brightly illuminated streets receive the most traffic. It would be interesting if some numerical data could be obtained from well-known stores in London showing how the diminution in light has affected custom. Certainly the change has done more than any event in recent years to bring home to the general public the importance of adequate lighting in the streets.

One result of the diminished public lighting will doubtless be that people will spend more of their evenings at home. The opportunity should therefore be taken to make the interior of the house as cheerful as possible and to see that the lighting is satisfactory and up-to-date. Let us hope that activity in this direction will partially counteract the diminution in lighting out of doors.

EFFECT OF DIMINISHED LIGHTING ON TRAFFIC.

This leads me to another important point—the effect of diminution of light on traffic and in causing possible accidents. Here it would be most useful for future guidance if a careful record of accidents in the streets could be kept. The available data are somewhat difficult to interpret. In some quarters it has been declared that the number of street casualties has considerably increased since the regulations came into force. On the other hand, the most recent official announcement suggests that this is not the case (although the fact that stress is laid on the desirability of special care on the part of motorists shows that the danger is recognised). But it may be pointed out that simultaneous with the change in the light the volume, and probably also the speed, of the traffic and also the number of people using the roadway, have enormously diminished. Moreover, it is obvious that by taking special

care in crossing streets, &c., people can avoid to a great extent accidents which would certainly occur if they went about their business in the ordinary manner. Therefore it should not be too readily assumed that the diminished lighting has had no effect, and could be permitted in normal times: whatever the number of accidents, it has certainly slowed down business, and would be intolerable in ordinary circumstances. Also there must be a limit in the reduction of illumination below which even great care would not avoid mishaps, and it is a question whether we are not nearing this limit at the present moment.

Again, it is well known that even in ordinary times the use of excessively bright headlights on motor-cars has been condemned as leading to accidents. In the present semi-darkness their danger has become evident, and on many cars the brilliancy has been diminished by inserting paper screens in front of the lenses. This is hardly a scientific method, since it practically destroys the value of the headlight for illuminating the roadway; a preferable plan would be to screen the lens in such a way as to restrict the rays below the horizontal. The chief thing is to prevent the stray rays striking and dazzling the eyes of people in the roadway.

Previous to the war attempts had already been made to improve the design of headlights and particularly to avoid those dazzling conditions which are occasionally met with and which may be a menace to the safety of the public. It is possible that the experience gained at the present moment may lead to permanent and more thorough regulations on this point.

GENERAL IMPRESSIONS OF THE PRESENT STREET LIGHTING.

It would be interesting to hear the impressions of those present as to the value, from an illuminating engineering standpoint, of the system of screening the lights at present in vogue. Is any modification of this method likely to find favour when once more we return to ordinary conditions? It has often been urged that the glare from modern street lamps is a decided drawback, and that a much better visual effect would be obtained if

these were screened from the eye. It has been suggested that the glare from modern powerful street lamps has sometimes been responsible for accidents, just in the same way as the dazzling effect of motor-car headlights is apt to be. This point has come before the notice of the authorities in times of peace, but has not perhaps been appreciated at its proper value. Now that they have had the experience of an entirely different variety of street lighting, their views as to what constitutes good illumination in the streets may undergo modification.

Possibly, too, the present conditions may reconcile the public (which has hitherto obstinately clung to the tradition of glare) to a milder method of illumination, and that screening with some form of translucent reflector may meet with approval. In order to avoid offending the eye, it would not of course be necessary to screen the lamps anything like so completely as at present, and provision could be made for sufficient light to pass upwards and sideways so as to illuminate the buildings at the sides of the street. A characteristic of the temporary method of lighting now in use is that practically *all* the available light is directed on the roadway and pavement. I think it will be generally agreed that from an æsthetic standpoint the method is not a success.

REDUCED LIGHTING IN PUBLIC VEHICLES.

Yet another change during the last few months has been the diminution in the amount of light in public vehicles. A few months ago we had a discussion before our Society on the lighting of tramways and railway carriages; it was pointed out that good illumination is now an effective method of attracting travellers. It would be interesting to know whether one could trace any distinct diversion of traffic to the underground railways—almost the only place where the illumination is “as usual”—while those who use the buses and the tram-cars travel in a dim and religious light.

There is need for some judgment in the means adopted to reduce the light in these public vehicles. Here again the illuminating engineer is inclined to ask whether it is inevitable to cut down the

light as a whole by obscuring lamp bulbs with blue lacquer, or whether it would not answer merely to equip lamps in suitable shades leaving enough light to read by, and yet rendering the vehicles sufficiently indistinguishable by night. The arrangements in some of the tramcars have been modified lately, and there is some indication of the acceptance of this idea.

SHOW-WINDOW LIGHTING.

The next point that deserves attention is the effect of present conditions on the lighting of the shops. Presumably there is no objection to a merchant illuminating the interior of his shops as brightly as he pleases, so that in this branch of work, apart from the natural depression in trade caused by the war, there should be no obstacle to illuminating engineering continuing as usual.

As regards the window lighting, the chief point of interest is that the recent regulations are driving entirely in the direction advocated by us for other reasons. It has been consistently pointed out that the finest effects in shop-window lighting are to be achieved by treating the window like a stage, where the brightly illuminated objects are made the chief points of interest and the lights themselves are concealed. When I advocated this method many years ago some criticism was expressed by the owners of several large stores. The misunderstanding apparently lay in the assumption that the screening of lights would mean a less satisfactory illumination—which of course is not the case. At the present time this method is employed by most of the leading stores of London, and time has shown the correctness of the views expressed at that time, which are now endorsed by the leading contractors.

I think it may be said with some certainty that a merchant who relied entirely on this principle of concealed lighting should not now find himself obliged to alter the lighting of his windows to any great extent; perhaps in the case of wide streets the upper parts of the windows have to be masked or the canopy let down so as to screen the window from above without interfering with its being seen from the pavement.

On the other hand, the merchant who has relied on exceedingly bright lamps placed in the window suffers for his neglect of the principles of illuminating engineering. The authorities have required that such lights should be screened, and also that powerful lamps outside the shops should be covered by screens which cover the lamps from view and prevent any large amount of light falling on the pavement. In this respect they are merely carrying further the practice in the City of London, where there has been for some time a regulation that such lamps should be screened on the side facing the roadway. In this respect, therefore, as in the case of streetlighting, the present regulations are, to a certain extent, in the same directions as the recommendations of our Society, though doubtless carried to a point which would hardly be desired in times of peace.

Naturally the present regulations have had the effect of practically eliminating what is known as "parade lighting." In some cases the lamps employed for parade lighting are so powerful that some means of softening the light might be encouraged even in times of peace. But the chief thing to be guarded against, to my mind, is the sudden change from a comparatively low illumination to a brilliantly lighted area; such abrupt changes might be avoided by "grading the lighting," *i.e.*, by using lamps of progressively increasing candle-power so that the change in illumination is not so sudden.

A walk round any of the streets of London just now reveals an extraordinary diversity in the appearance of shops, and in the means adopted to comply with the police regulations. Almost invariably the outside lamps are extinguished. Lamps in the window are swathed in varied degrees of opacity and colour; in some instances the fact that the bare lamp-bulbs have been tinted blue is apparently accepted as complying with the requirements of the authorities. Needless to say, these amateur efforts result in very indifferent window lighting, and it may safely be said that in most cases it would pay the merchant to adopt concealed lighting in preference. It is to be noted that various firms have rightly taken the opportunity to urge the advisa-

bility of methods of this kind, and at the present moment there should be a demand for such methods of conversion.

It is quite obvious that the problem of deciding when and how lights should be diminished is an exceedingly difficult one for the ordinary police constable to determine, and it seems reasonable to suppose that the help of some members of our Society, who are accustomed to dealing with problems of this kind, would be of value to the authorities. It would perhaps be desirable to have a rough standard of permissible intrinsic brilliancy. Past experiments with searchlights have shown, however, that the connection between the brightness of an object and the distance at which it is visible is by no means a simple one: it may be questioned, for example, whether merely colouring a lamp-bulb or surrounding it with crinkly tissue paper is a very effectual method of making it less conspicuous from above.

The use of concealed methods of lighting should surely be encouraged and it seems reasonable to suggest that a general recommendation on these lines would go far towards supplying a simple rule for merchants to follow. If, in addition, some limit to the illumination is necessary in order to avoid undue lighting of the pavement it should not be very difficult to frame an additional recommendation on this point for the guidance of contractors. There does seem a need for some more explicit recommendations which could be generally adopted and which would leave as little as possible to personal interpretation. If there is to be a penalty for non-compliance with official recommendations the consumer and the contractor should be given definite information as to what is permissible and what is not. This applies particularly strongly to new installations which will have to be designed in such a way as to meet the present conditions.

ILLUMINATED SIGNS.

Somewhat similar considerations apply to illuminated signs. Naturally the first step of the authorities has been to extinguish the giant signs (such as those on the Embankment) which form such conspicuous landmarks), but care should be taken that a regulation of this kind does not assume too arbitrary a character:

there are many mildly luminous and quite inoffensive small signs which should not be included in the above category.

The use of an illuminated fascia carrying the name of the shop or an advertisement should also be considered. It may serve to screen the lamps which are placed at the top of the window, and, provided the brightness is not much above that of the contents of the window, there would not seem to be any objection to this form of transparency sign. But in any case the existing regulations could be complied with by merely using some form of silk shade for the time being.

As regards large signs of the kind referred to above, one may sympathise with the view that many of these huge advertisements are inartistic. Some of these signs have been placed in undesirable positions, and do not add to the beautification of London. Their extinction at the present moment is not entirely a cause for regret. Possibly the effect of the present conditions may be that they will in future be restricted to certain areas. But those artists and architects who have described these signs as "eyesores" should recognise the duty of educating the public to appreciate the artistic possibilities of the illuminated sign.

The whole question is one of extreme importance to the merchant in London, and it is considered that the present measures, however necessary for safety, have a crippling effect on trade and a depressing effect generally. It is therefore worth while to take pains to render the measures now being taken as little onerous as possible. Seeing that our Society includes representatives of all sections of the public—makers of lighting appliances, sellers of gas and electricity, and the consumer—we are vitally interested in the matter, and it occurred to me that a discussion might give rise to some useful suggestions.

Although the changes in lighting have inevitably been productive of some inconvenience we must of course acquiesce in measures which are considered desirable in the interests of public safety.

Meantime we may expect that some ultimate good from the illuminating engineering standpoint will result. I may conclude by a brief summary of the chief points suggested in this contribution.

(1) Present circumstances have brought home to the public the vital importance of good illumination. After having experienced such a fundamental change the authorities may be more disposed to make experiments in the future; the public should appreciate better the need for expert guidance and recognise the valuable services so far rendered by our Society.

(2) After the war is over we may not revert to exactly the same methods as were previously employed; greater attention should be paid to the screening of public lamps with a view to avoiding glare, and the importance of a fairly uniform illumination will be better understood.

(3) Present experience is demonstrating the importance of carefully designed public lighting in the interests of traffic. Excessively brilliant headlights on motor-vehicles are recognised to be inconvenient, and may possibly be restricted when we return to normal conditions.

(4) The attention of merchants has been drawn to the benefits of good shop-lighting. An impetus has been given to "concealed window lighting," and the effect should persist afterwards. Meantime there seems a need for some more explicit advice as to what is permissible. The Illuminating Engineering Society might be of service to the authorities by preparing some suggestions as to how the official recommendations can best be complied with.

(5) The extinction of some of the more prominent illuminated signs has been, from the artistic standpoint, an advantage. It may be decided to make some restrictions as to the nature of such signs, and the localities in which they are permissible, and attention should be given to the preparation of illuminated signs for many purposes and of a more artistic kind.

ILLUMINATING ENGINEERING IN WAR TIME.

DISCUSSION.

The CHAIRMAN, speaking with regard to the letter, a copy of which Mr. Gaster had put upon the screen, said this only pointed out that a limited amount of lighting could be used in the interior of shops after 6 p.m., but from the lantern slides shown by Mr. Gaster it would seem that there were a great many examples of interior lighting which would not be allowed by the police under the present regulations. In these illustrations it was very noticeable that although the lighting was entirely inside, nevertheless the pavements were brilliantly illuminated by the reflection of the light from white articles, mirrors, etc., in the windows. Harrods was an example of this, and he believed they had been compelled by the police to screen, very materially at any rate, the upper portion of the illumination of their windows. The trouble was to know exactly what the authorities would pass and what they would not pass.

He would like to emphasise what Mr. Gaster had said—namely, that the object of this discussion was not in any way to criticise what the authorities had thought it necessary to do for the protection of London. That was certainly not their province, and the Council would feel that it was very much out of place if any criticism of the Admiralty or War Office was made in the present critical times. We all might have our own opinions as to the likelihood of Zeppelins coming here, and we also had a pretty good idea of the sort of reception they would get if they did come, but if the darkening of London was going to save lives in any circumstances then those who supplied the illuminant certainly would not be found to raise their voice against any regulations made by the authorities.

All we wanted to find out was what was permissible and what was not, because there was not, at the present time, very great uniformity in the instructions on this point. There was a variety of police practice in different parts of London, and if, as the result of this discussion, it was possible to make suggestions to the

authorities which would bring about the result aimed at whilst enabling the traders of London more effectively to illuminate the interiors of their shops, it would not have been a useless one.

Two of the illustrations shown by Mr. Gaster were of the showroom of the Gas Light and Coke Co. at Edgware Road, where they had succeeded in meeting the requirements of the police whilst not diminishing the illumination inside.* That was achieved by putting reflector lights close to the glass high up in the windows and also low down in the windows and covering the glass for a considerable area in front of the lights both above and below with blue paper. The result was that no direct rays of light whatever fell on the pavement outside the shop window and very little reflected illumination escaped, and that only horizontally, so that the pavement was entirely in gloom. The result was rather effective from the shopman's point of view, because it gave something of a peep-show effect. There was a broad band of obscure window above and below with plenty of light at the eye level for people to look into the shop. This idea had been followed out by other shopkeepers, and the police were very satisfied with it.

With regard to Mr. Gaster's suggestion that a careful record of accidents should be kept, it would be very necessary to differentiate between accidents in the day time and those occurring after lighting up, because statistics could be very misleading if they did not give all the factors in the situation. Undoubtedly at the present time greater care was being taken by drivers and greater care was also being taken by people to be "quick" rather than "dead," and these factors alone rather tended to vitiate any statistical comparisons that might be made with what had happened in the past in normal times. He was afraid he could

* This window was illustrated in *The Illuminating Engineer*, Dec. 1914, p. 567.

not agree with Mr. Gaster that the glare from modern powerful street lamps was responsible for accidents. He was not aware of any instances of street-lighting in London, either by gas or electricity, which could be said to be dazzling in their effect, either to pedestrians or drivers. He did not know if anybody could say whether Selfridge's had had to reduce the amount of interior lighting used for their windows. In this case the lighting was entirely concealed, but at the same time it brilliantly illuminated the pavement outside the shop.

With regard to outside lamps, these were not used merely for lighting the goods in the windows, but were used very largely, as Mr. Gaster had indicated in his photograph of the Lewisham High Road, for the purpose of directing the public to the road at night-time, because this brilliant illumination made night-shopping a pleasure and also perfectly safe. As to the suggestion that in this class of parade lighting the illumination should gradually work up to a maximum and then dwindle down again, he was afraid that the shopkeepers at the beginning and end of the parade would not welcome the suggestion, as the lamps outside their shops would be considerably less powerful than outside the shop of the man halfway along. He was afraid there would be a distinct practical objection to that theoretical suggestion.

He hoped the result of the discussion would be some practical suggestions which could be placed before the authorities which would assist them as well as assist the tradesmen. He believed there was a representative from the Office of Works present which had control of this matter on behalf of the Admiralty. Possibly it might be too much to ask him to take part of the discussion, but any remarks he felt at liberty to make would be listened to with great interest by those present.

Mr. J. W. T. WALSH (National Physical Laboratory) spoke upon the question of glaring motor-car head-lights, and apologised for the absence of Mr. Paterson, who had gone into this matter a good deal at the National Physical Laboratory. Recently, he said, we had seen such devices as the swathing of motor-car head-

lights in tissue paper or some other translucent material. One patriotic motorist he had noticed had used Union Jacks for this purpose, with the result that from the driver's point of view the head-light was reduced to the efficiency of an ordinary bicycle lamp.

Mr. Gaster had suggested that the head-light beam should be kept below the horizontal. Surely he must mean *above* the horizontal, but even so the suggestion, he thought, was a little too sweeping, because it was clear that the portion of the beam which would tend to dazzle anyone approaching a motor-car—provided he were on his own side of the road—would not be the whole upper portion of the beam but only that segment of it which lay to the driver's right-hand side. Any device, therefore, which would result in cutting down this right-hand top segment would entirely screen from dazzle anyone approaching the car provided he kept to the left of the road. It had been found possible to adapt both acetylene and electric light sources so as to produce head-light beams in which this right-hand top segment was entirely eliminated, and the slide which he showed illustrated the effect produced.



This particular photograph was taken with two motor-car head-lights which together over the main portion of the beam were equivalent to 1,400 candles. In the obscured segment, however, this

intensity was reduced to 14 candles without any appreciable diminution of the light produced over the remainder of the beam. Another device had been found useful by Mr. Paterson in connection with the suggestions made at various times that brilliant head-lights should be wholly diminished when driving through towns. This consisted of a small metal screen placed between the source of light and the mirror so as to render inoperative either the whole or any portion of it which might be desirable. By this means the intensity of the beam could be reduced at will without sensibly affecting its directiveness.

Mr. F. BAILEY (City of London Electric Lighting Co.), speaking of his experiences with the street lighting of the City of London, said he had found it was not an easy matter to screen arc lamps at short notice. In the case of the City, he had to screen a large number of lamps so that the light did not illuminate the sides of buildings for more than six feet from the ground. In order to accomplish this he painted the top of the globe, but having in view the possibility of fog and the need for suddenly increasing the illumination considerably, he succeeded in convincing the authorities that it would be better to leave a number of lamps with clear globes and only light them in case of emergency. Unfortunately fogs did not come as frequently as the supply authorities might desire, and therefore there had been very little opportunity of trying the effect. Consequently, as might be well known to many, those lamps which were not in use developed eccentricities due to the effect of rain and condensation, with the result that a series of faults had occurred which rendered it unwise to rely upon the lamps for emergency. The only alternative was to dry them out by running them in the daytime, and this had brought down upon him much unkind criticism to the effect that he did not know what he was doing and was wasting current.

Undoubtedly the present lighting of our streets was producing a feeling of gloom and depression which would remain in the memories of all those who had to endure it, for the rest of their lives. Personally, he could not help feeling that it must have a good effect upon recruiting

because he could not imagine anyone staying in London under its present conditions when they could have a very much better time at the Front.

With regard to the lighting of rifle ranges, perhaps Mr. Gaster was referring to miniature ranges, but it occurred to him that outside full distance ranges might also be treated in the same way. With miniature ranges there was not much scope for invention, but it was astonishing how badly lighted they were. He had given some attention to the matter in connection with a miniature range which had been set up for his work-people, and it added considerably to the cheerfulness of the men using the range. Generally these ranges suffered from too much gloom at the firing line and too much brilliancy in front of the target. That gave a bad impression. The lighting of full-sized ranges should have the effect of enabling men to become efficient much more quickly and it should not be too costly to have two sources of lighting, one for the targets and one for the firing line.

Mr. W. J. LIBERTY said it was remarkable how people had become "acclimatised" to the reduced quantity of lighting in London. As to accidents, records were being kept, and it might be interesting to know that in the City of London accidents had been less; in fact, there had not been one collision at any "rests" within the last three months. In the City of London the normal lighting was something like $1\frac{1}{4}$ million c.p., having been recently increased from about 688,000 c.p., but at present they had dropped the million and gone down to the quarter. The effect of the reduced lighting in obscuring London was such that from the dome of St. Paul's at midnight it had been quite impossible to locate certain spots. This gives an idea of the effectiveness of the scheme, and the change had been accomplished during the short interval from the receipt of the instructions at 11.30 on the same morning.

As things were now, there was no need to fear fogs because he believed the authorities had everything in readiness, as had been mentioned by Mr. Bailey. Various methods had been suggested for bringing about this result, and it was most easy to accomplish where central

lighting was adopted, the circuits being so arranged that the lamps were in alternation, the shutting down of half the circuits put every other lamp out; these were left unshaded and in time of fog the "idle" circuits were put into lighting; this with shaded lighting was found effectual so far as the white misty fog that they had yet experienced.

There were various methods in different localities for reducing the public lighting. Some authorities had taken great blocks of lighting away altogether; in others alternate lamps had been extinguished, and where lamps were staggered across the road the result was the putting out of one side of the road entirely, the other side with the lamps all in. In the inner ring of London with central roadway lighting it was easy to adopt the method of having every other lamp extinguished. It was necessary to go back 50 years to find street lighting down to anything like the present level, when flat flame burners, consuming five cubic feet per hour and giving $2\frac{1}{2}$ candles per cub. foot of gas were in use, but although smaller units than those now used were employed, the lamps were then placed closer together, so that there was not the spottiness that was now noticeable.

After all, so far as the supplies of the illuminants were concerned, the public lighting was not of the greatest importance, seeing that it represented only about five per cent. of the total output. Interior lighting, however, was the question which was most concerning shop-keepers and others and he believed it had been the general impression that they could not have anything like the normal lighting at any time. This, however, was not the case and the Society might take steps to bring it before shop-keepers that they could have all their interior lights going from 3 or 3.30 until 6 o'clock, this giving them at least $2\frac{1}{2}$ hours' good lighting. This knowledge might be of considerable value having regard to the approach of Christmas and the school holidays. Shopkeepers did not seem to be aware of this, although it was mentioned in the last order issued. If it could be brought to the notice of the shopkeepers as an outcome of this meeting, by the Council of this Society, it would add to the cheerfulness of the

streets during the busy period and would cause people to come out on "shopping bent," and would mean a great deal in the way of spending and of trade and tend to keep the financial wheels going round. With regard to illuminated whiskey signs, he did not believe one noggin less of whiskey had been drunk as the result of putting these signs out of use, and from the æsthetic point of view he did not think many people would regret if they were not lighted again.

Mr. T. E. RITCHIE pointed out that the authorities had to deal with the present lighting of London, not so much from the standpoint of the man on the ground level as from that of the man far above the ground. He did not think that much progress in increasing the amount of light would take place until there were available records of the very careful and systematic work in this direction now being made. He believed, however, that it would be found to be distinctly better to adhere to a moderate value of illumination and a reasonable degree of uniformity, rather than the extraordinary spotty effect which prevailed at present.

Particulars had been asked for as to measurements of illumination at the present time. There was one case he could mention, that of a shopkeeper whose lighting was objected to owing to reflection upon the pavement in front of his window. This illumination at this point was found to be $1\frac{1}{4}$ foot-candles; yet, not far away, there was a very brightly lighted patch under a lamp, the average of which was nearly 16 foot-candles. If, as Mr. Bailey had said, the instructions were that no building should be lighted for a greater height than six feet above ground he could not understand why an objection was taken to this relatively low illumination of $1\frac{1}{4}$ foot-candles, since, in any case, the width of the roadway would be defined if the buildings were lighted.

He might also mention one very practical system of street-lighting according to which ten-ampère flame arc lamps are being arranged on alternate circuits so that every other lamp could be switched on. Instead, however, of blacking the upper portions of the globes, arrangements were made for the light

from each lamp on one circuit to be reduced by half; in this way it was possible to have every alternate lamp on full power or half power. The system had the desirable quality of flexibility without impairing the efficiency of the lamps, although, of course, the total current consumed was less.

Mr. J. MACINTYRE (H.M. Office of Works) said it was naturally impossible for him to say much in a general discussion in regard to street lighting regulations, but he had profited by the discussion and hoped that to the same extent his department would also profit.

One matter which had interested him in a private capacity was the lighting of rifle ranges. Anyone who had experience of shooting rabbits at dusk knew that in these circumstances a man who was ordinarily a splendid marksman would often prove a complete failure. At the Front it would often be necessary to shoot in the twilight or even in the dark, and it was therefore questionable whether men trained in their firing at perfectly illuminated ranges would turn out the best shots under war conditions.

He agreed that when the order came for turning up the lights once more it would be a pity to revert to the old methods completely. The present was a favourable moment for considering what improvements could be carried out, and certainly in many cases there was room for improvement.

Mr. A. CUNNINGTON (London & South Western Railway) said he had been concerned in dealing with goods and shunting yards under the present abnormal conditions of lighting.

The difficulty in connection with such areas was that a considerable amount of light was essential to the working of the traffic, and they had to adjust the lamps so as to avoid on the one hand serious congestion of the yard and on the other providing a conspicuous mark for hostile aircraft.

It was at first thought sufficient to screen the lamps from above, but aerial patrols reported that this was not sufficient, and finally the light was reduced to a zone subtending about 45 degrees, 35 degrees being obscured at

the bottom and 10 degrees below the horizontal. So far as he knew this was quite satisfactory to the authorities and it enabled the work to be carried on, for although the average horizontal illumination was about one-tenth what it was before, the effective lighting, *i.e.* vertical illumination at the top of the trucks, was not materially reduced. Incidentally this showed that minimum horizontal illumination was not a good criterion for the lighting of goods yards. As the result of illumination measurements made under the present conditions he had found many spots where the horizontal illumination at three feet above ground was too low to be accurately observed, and yet shunters were able to work by the light falling on the top edges of trucks and vans.

Mr. Gaster had referred in his paper to the reduced lighting in public vehicles. In this connection he had noticed recently in a L.C.C. tramcar that a man was reading quite comfortably with an illumination which he afterwards found to be only 0.5 foot-candle. This might seem low in comparison with the value of two to three foot-candles for reading suggested in a pamphlet of the Illuminating Engineering Society, but further measurements with the Lumeter revealed that the general illumination of the car was only one-fifth of this value, and he believed that it was due to the very subdued light of the surroundings that the man was able to read without straining his eyes. On account of the accommodating power of the eyes, he thought much depended in these cases on the relation between the light on the book or paper and that on the surroundings.

He ventured to suggest that there were many places such as shop-fronts, "parades," and even certain of the main streets of London, where the present reduction in lighting might teach some lessons in better grading of illumination and avoidance of sharp contrasts. He certainly thought Mr. Bailey had exaggerated the terrors of reduced lighting, and he could not agree that the result was so very depressing, especially in the suburbs, where only alternate lamps were extinguished. It was interesting to recall the changes that had taken place in the last 15 years in regard to standards of suburban street lighting. From measure-

ments which he had made in the district in which he lived, where they happened to have every type of street lamp except the flat flame burner, he found the following rough proportions existed. Taking the flat-flame burner, which was the standard 15 years ago, as the unit, upright mantles gave six times as much light, the inverted mantle gave ten times, and electric street lamps (100-watt metallic lamps) came somewhere between the last two. The above figures were for measurements of candle-power at 10° below the horizontal. The normal present-day lighting was therefore about 10 times that of 15 years ago, and so with alternate lamps extinguished we still have five times more light in the streets than in 1900. This showed in a striking manner how greatly the standard of street lighting had increased in recent years.

Mr. F. W. WILLCOX (British Thomson-Houston Co.) referred to the amount of wasted current now caused by the methods of dimming street lamps, many of which, he said, it would be a kindness to put out, as they did not add anything to the illumination. It was a pity there was not more general adoption of the plan used in Oxford Street, where the arc lamps had been dispensed with and incandescent lamps with metal dome reflectors used instead. This plan might almost be used in normal times to cut down the illumination in clear weather, using the arc lamps in foggy weather.

With regard to interior lighting, much more could be accomplished in conforming to the new regulations with harmony to proper lighting effects if correct methods of lighting were used instead of the crude applications so generally employed.

With regard to Selfridge's, he had recently passed these premises and noticed that the windows were as brilliantly lighted as ever. The use of sunshade awnings over each window solved the problem. His general impression was that those shop windows which were best lighted with concealed lighting had suffered the least under the new regulations, as all that it had been necessary for them to do was to use a curtain or shade of some sort to dim the light falling on the side walk or pavement.

Mr. C. BUSSELL remarked on the diversity in practice in lighting streets in the suburbs; for example, in the road where he lived there were only two lights, but in an adjacent road five lights in the same length. There were also roads some distance out of London on which flat flame burners were still in use. The effect of increasing the intervals between lamps was apt to dazzle the motorist, since he came upon the lamp suddenly when his eyes had become accustomed to the darkness.

Mr. F. C. TILLEY said that one good effect of the war must surely be to bring about an improvement in shop-lighting methods in the future as many a shop-keeper who was content in normal times to go on in a more or less old-fashioned way had now been compelled to take a keener interest in the question of properly lighting his shop windows in order to attract the public. He might even feel the necessity of calling in expert assistance to aid him and in this direction the members of the Society could do good work. He did not wish to express any opinion whether the central lighting or side lighting of streets was the best, but those who compare the two methods under the existing conditions would have a good opportunity of judging their relative advantages. He agreed that it would be a considerable assistance to have a definite decision as to the degree of lighting which could be adopted for shop windows and no doubt the Chairman of the Society would do his best to bring the matter before the authorities.

Mr. L. GASTER, in reply, congratulated Mr. Goodenough on the lighting arrangements at the Edgware Road showroom. He thought that, according to the existing practice of the authorities, it might reasonably be expected that adequate lighting would be allowed inside the shop, provided no very brilliant objects were visible from outside and the rays of light illuminated the contents of the window and not the pavement. Doubtless in the case of shops at corners or facing open spaces, &c., the use of an awning might be desirable to screen the lights from above. He agreed with Mr. Willcox that many shops were still very unscientifically lighted, and he thought it

would be found that those that adopted the concealed lighting complied most readily with the authorities' requirements.

With regard to parade lighting, he thought that the conditions he had suggested might be obtained by gradually increasing the illumination as one approached the parade lighting proper. All the shops in the row might enjoy the same amount of light; what he suggested was that the abrupt transition where the parade lighting began and ended should, if possible, be avoided.

It could hardly be denied that there was some degree of glare from certain forms of street lighting. Instances could be mentioned of drivers being dazzled by passing from a comparatively dark street into a very bright one, and accidents have been ascribed to this cause. The fact that in some cities the lighting of side streets was progressively strengthened as one approached a main thoroughfare showed that this possibility was recognised.

He was interested in the description of Mr. Walsh's design for headlights. There seemed to be a misunderstanding as to his (Mr. Gaster's) suggestion, that the beam of light should be confined below the horizontal. Clearly what was required was that the rays of light, after emerging from the lens, should not dazzle the eyes of drivers and pedestrians, and should therefore be kept below the horizontal, as shown in Mr. Walsh's own photograph.

Mr. Bailey and Mr. Ritchie corroborated his view as to the desirability of making the lighting arrangements flexible so that the illumination could be increased in case of fog. He agreed with Mr. Bailey as to the value of good artificial lighting for rifle ranges. Mr. Macintyre had pointed out that men should learn to shoot under trying conditions, for example in the dusk. This was a matter for the consideration of the military authorities. He thought, however, that if artificial light was used on a miniature rifle range it would surely be best to have this light as perfect as possible, especially as these ranges were used mainly for beginners. Experience of trying conditions was best obtained in daylight. He was glad to note Mr. Macintyre's sympathetic remarks with regard to the value of this discussion.

Mr. Gaster added that he wished to congratulate Mr. Cunningham on the scientific methods used in darkening his company's goods yards. The data collected should be of considerable value for future reference.

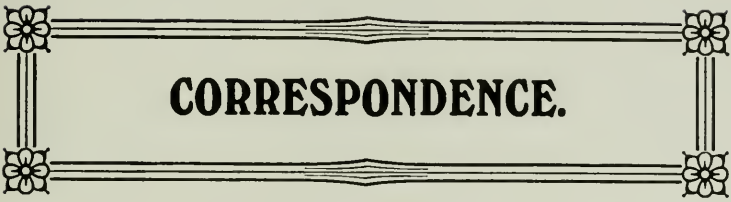
Mr. Liberty's data for the City of London were interesting, particularly his experience in looking from the top of St. Paul's by midnight. He understood that the present arrangements were considered satisfactory from the standpoint of the authorities; the problem was to meet their requirements and at the same time to dislocate business and daily life as little as possible.

The fact that the changes had been carried out with so little friction showed the forbearance of the police and the willingness of the public to make what sacrifices were necessary. However, he believed that, as Mr. Goodenough had said, the Society could assist the authorities in dealing with these problems, and he hoped that they might be instrumental in framing some more definite rules for the guidance of shopkeepers.

It had also been suggested that some members of the Society might volunteer to advise the authorities in case of any dispute, and personally he was quite prepared to do so.

He thought it would be agreed that the darkening of London was essentially a problem that should be solved by scientific lines. Clearly the measures to be taken in any street, or in arranging the lighting of a particular window, should depend on the local situation. For example, in a narrow street with high buildings it might be possible for shops to be quite brilliantly lighted, provided the illumination of the pavement was kept below a reasonable limit, so that the width of the street could not be detected. On the other hand special measures would be necessary in the cases of a shop at a corner, or facing a wide open space so as to be easily visible from above.

If this discussion led to a more general agreement as to the most scientific methods of shop-lighting and the requirements of street lighting, this alone would be a most useful result, and would justify the existence of this Society as a platform for the discussion of such important questions.



CORRESPONDENCE.

CONDITIONS IN PARIS IN WAR TIME.

THE following is a translation of a portion of a letter received from one of our corresponding members in Paris, describing the present lighting conditions in that city:—

As regards the illumination of Paris, on which you have been good enough to make inquiries, there are a few points that may interest you:—

(1) The lighting has been very much diminished, especially from 8 p.m. onwards, and on account of the closing of shops.

The public lighting in the streets in the centre of Paris is in many cases little more than a half or a third of that prevailing in ordinary times, and the suburbs are even less illuminated. The district round the Eiffel Tower, where I live, is systematically placed in obscurity, notably by the extinction of all the lights in the Champ du Mars. In order to avoid the possibility of the enemy locating the Eiffel Tower during the night the illumination on the bridges over the Seine has even been suppressed and the quays left almost in complete darkness. However, no aeroplane has made its appearance round here by night, and all the attacks have been made in the day time, particularly in foggy weather, such as naturally hampers the constant surveillance of the air maintained by French aeroplanes.

(2) As regards the effects of the war on the lighting industry, these are not very serious. The Société d'Incandescence par le Gaz has great stocks of thoria and ceria, and up to the present can keep pace with the consumption of incandescent mantles. There is also a company at Clichy which can furnish rare earths obtained from the sand from Brazil.

Electric glow lamps are likewise produced in France by many companies which have been engaged in the manufacture of metal filament lamps for several years, and which can produce enough to meet the consumption. Only those companies which are German, or have German connections, have closed their works, and their premises will be shortly placed under supervision.

The situation in regard to carbons for arc lamps is more difficult, because the works of Fabius Henrion (Pagny sur Moselle) and the Société Auer (Mainbottel) are in the territory actually occupied by the Germans. But there still remain stocks in the Parisian branches of these companies, and there are also works at Nanterre and Frouard which are actively engaged in manufacturing carbons, particularly those of the non-mineralised variety.

As regards mineralised carbons, some difficulty may be expected if the war is prolonged; possibly the demand may render necessary the introduction of foreign carbons; but the greater number of the big consumers have diminished their consumption. Many works have closed, the public lighting has been so reduced, and in many cases carbons of a simpler kind are now being used; these facts will help us to cope with the situation. However, the Cie. Parisienne de Distribution d'Électricité has sufficient stocks of mineralised carbons to assure the lighting of the streets during the probable duration of the war, in view of the present diminution in illumination. . . .

. . . . The darkening of Paris by night arises not so much from the fact that the lighting has been diminished by a half or two-thirds as from the closing of the shops after 8 p.m. (There is talk

of allowing the cafés to be open up to 10 p.m.) No depression in spirits has been caused by the reduction in light, nor has there been any increase in accidents, owing to the exodus of about one million of the inhabitants at the end of August (of whom the greater part have not yet returned), and the requisition of the omnibuses and a large number of automobiles for military purposes. Thus, while the lighting is diminished the amount of traffic is also very much less.

SHOP LIGHTING IN WAR TIME.

DEAR SIR,

Owing to the police regulations, the subject of shop window lighting has received more attention recently than it has ever done. A walk down any of our leading shopping thoroughfares on any evening will be rewarded by the sight of many amateurish attempts at light diminution. A much-favoured method is the fixing of tissue paper shades round bare lamps—this is not only ineffective from an illumination standpoint, but is a distinct source of danger, as witnessed by the large amount of badly scorched tissue

paper seen. As a result of the lack of illuminating knowledge the results achieved are, more often than not, gained at the expense of practically the total sales-value of the show window itself. Yet it is quite possible to light a window in such a way as to ensure a brilliant light on the goods and, at the same time, avoid glare on the pavement.

The British Thomson-Houston Company, Ltd., have, as you know, had a large amount of experience in shop lighting, both for the inside of the shop and for the show window. Those of our customers who installed concealed lighting *before* the war have had cause to congratulate themselves *since* the war, as they have not been called upon to make few if any alterations in their lighting arrangements.

It is with a desire to assist your readers that I am writing this letter to inform them that they can call upon our illuminating engineers for free advice as to the lighting of windows in an efficient and approved manner.

Yours very truly,

F. W. WILLCOX,

General Manager, Lamp and
Wiring Supplies Dept., British
Thomson-Houston Co., Ltd.

LIGHTING IN WAR TIME.

A FEW INCIDENTS OF THE PAST MONTH.

A NEW order has been issued by the authorities requiring: (1) the extinction of all lights for outside advertising or illumination of shop-fronts. (The uncertainty as to what lights were "powerful" led to the evasion of the order.) (2) That all vehicles should carry a red light in the rear. (In the present conditions of the streets this is necessary to protect vehicles from being run into from behind.)

According to the *Gas World* Mr. A. E. Broadberry has been able to obtain some relaxation of the existing restrictions on public lighting at Tottenham. The

police have now arranged for six inches of clear glass to be left on the lamps, whereas formerly 3½—4 inches was common. With the present arrangement the rays pass from one lamp to another, thus giving much more even illumination and less of the "spotty" effect.

A new order has been issued in Birmingham containing more definite instructions as to the diminution in light. The order makes special reference to the shading and extinction of street lamps, the turning out of conspicuous sky-signs, the obscuring of lighted roof areas, and the reduction of illumination in tramcars. In Scarborough "somewhat drastic orders" are also in force requiring the use of blinds in all houses after 6 p.m., and the total extinction of street lamps after 11 o'clock at night.



TOPICAL AND INDUSTRIAL SECTION.

— • • • —

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

MODERN LIGHTING FITTINGS IN THE EAST.

THE cover of a catalogue (No. 9), issued by the **Wardle Engineering Co.** (Deansgate, Manchester), contains a picturesque photograph, showing the use of the "Barrow" Suspension Device in a large city in Central India. This is one of the most interesting instances we have met for some time of the introduction of modern illuminants in Eastern surroundings. Here we have a characteristic Indian bazaar, which for centuries has relied upon the dim illumination of oil lamps. Now we find the streets lighted by incandescent lamps in a modern way equipped with the Barrow suspension device— an arrangement which has already been widely adopted in this country.

As the name implies, it was first used by the Barrow Corporation, and a number of examples are to be seen in London (*e.g.*, in Prince Regent's Lane, West Ham, and Green Lanes, New Southgate). The double support of the spanning wire, reinforced by the suspension wire, has the effect of preventing any undue vibration from the wind, and yet allows just sufficient "give" to withstand the force of heavy gales. The method

of suspension is also stated to have entirely overcome any effects on the filaments of lamps, due to the vibration of tram poles caused by the passing cars.



The "Barrow" Suspension Device in an Indian City.

Other interesting items in this catalogue are the "Workslite" fittings for use with the half-watt lamps in factories, the "Inverlite" dust-proof fittings for indoor lighting, and the "Orient" lanterns, the finished case of which resembles in shape the domes seen in our illustration.

SHOP LIGHTING DESIGN.

THROUGH the courtesy of the British Thomson-Houston Co. we have been given the opportunity of examining a delightfully got-up portfolio utilised by the engineering staff of the firm in dealing with the planning and specifying of interior lighting, and as an assistance to architects. These data have been prepared by the National X-Ray Reflector Co. of Chicago. One section is devoted to an illustrated booklet on "Planning and Specifying Interior Lighting," in which excellent photographs of a very varied series of lighting installations in schools, hotels, railway stations, &c., is reproduced. Other special installations include offices with "artificial skylight" illumination, and a series of hotels in which indirect lighting on the pedestal system is employed.

What, however, impressed us most was the series of plates in which the position and particulars of the type of unit, the consumption for a given area, the resultant illumination in foot-candles and other data are grouped together, together with a photo of the resultant effect. This series of plates covers the most diverse problems, but the series that interests us most at the present moment is that dealing with shop lighting.

By the courtesy of the British Thomson-Houston Co. we are reproducing on the opposite page a typical chart dealing with this subject. The figures necessary come out rather small, and we have therefore deliberately selected one of the least elaborate of the series. However, it serves to show the ingenious manner in which the design of the lighting system is indicated. We do not recollect having seen a more complete series of engineering data, and the collection illustrates very well modern enterprise in scientific illumination.

OLD MODELS AND NEW METHODS.

THE above is the title of a pleasing little booklet on fixtures by Mr. George Verity. It is attractively printed on rough paper; and the illustrations thereon, by the collotype process, are distinctly unusual in style. The transition from the old to the new, and particularly the adaptation of modern methods to the lighting of interiors in an old and traditional style is pleasantly described and some instances—such as the fittings at the Royal Naval College at Greenwich based on the original designs of Sir Christopher Wren—are quoted.

An interesting section of the book is that dealing with indirect and semi-indirect fittings. Some artistic types are shown, notably those using Wedgwood ware.

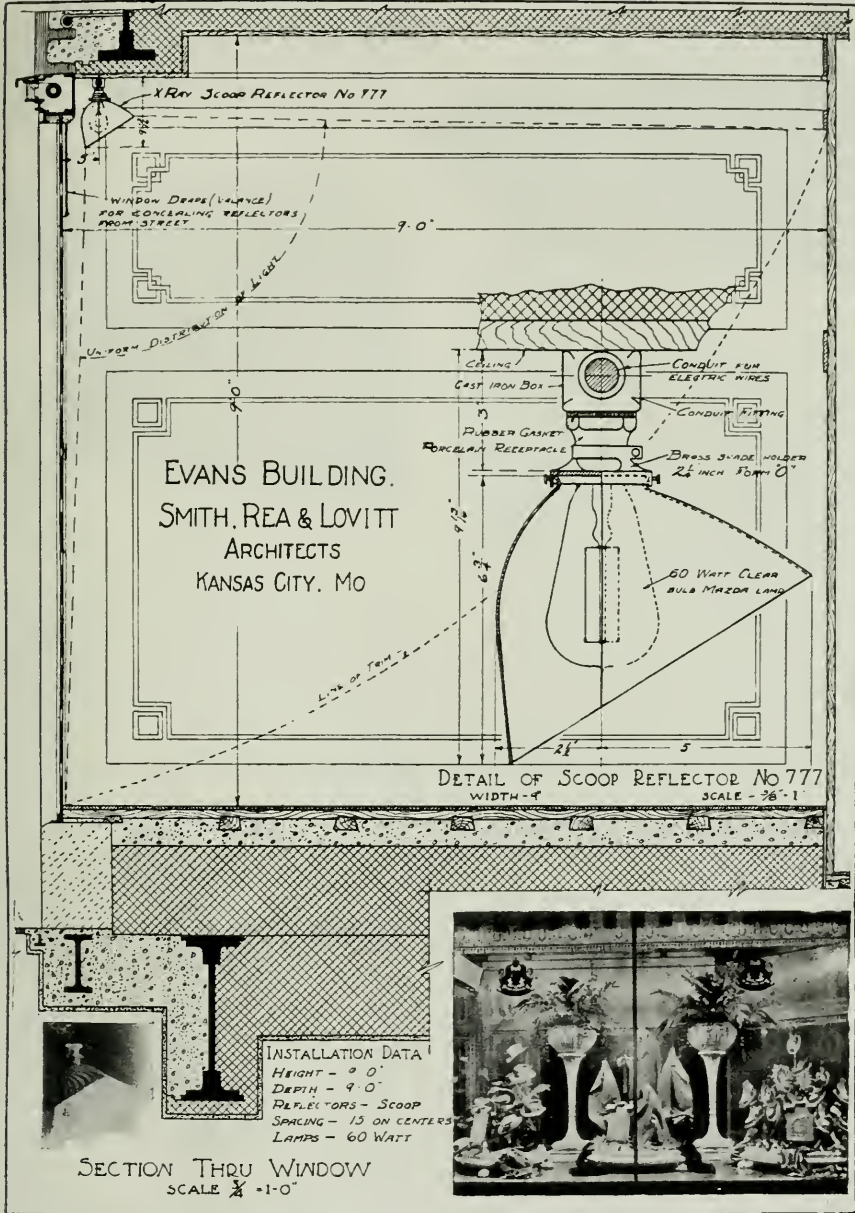
It may be mentioned that since 1819 Verity's have dealt successively with candles, oil, gas and electric lighting, so that they have had ample experience of the bearing of the changes in modern illuminants on fixture design. One of the illustrations shows what is presumably the first electric light fitting in this country—the "electrolier," designed to resemble a basket of flowers and named by analogy with the gasolier, which was exhibited at the Crystal Palace Electrical Exhibition in 1882.



His Own Design

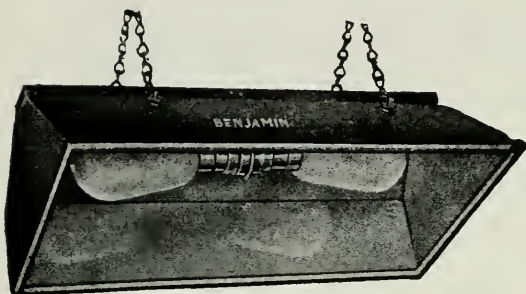
From "Old Models and New Methods."

X-Ray Reflectors For SHOW WINDOWS



A typical chart, containing data on show window lighting, as prepared by the National X-Ray Reflector Co. of Chicago, U.S.A.

BENJAMIN SHOP WINDOW LIGHTING REFLECTORS.



"Extensive" shop window reflector.

IN our last number we pointed out that at the present moment scientifically designed shop window reflectors have a special value. Seeing that the use of outside lights is now forbidden, the object of the merchants should be to concentrate their attention in lighting their windows on the stage principle. They should make use of reflectors which not only throw the light on to the goods but *do not allow the rays to escape out through the windows and light up the pavement.*

The new Benjamin reflectors which are illustrated on this page seem to be designed with a view to achieving these results; as the diagrams show, they can be tilted so as to keep the entire flux of light within the window. They are made in two types, "intensive" and "extensive," devoted respectively to shallow and relatively deep windows.

We notice that the Benjamin Electric Ltd. give a useful formula for window lighting as follows:—

$$\text{Number of Watts required} = \frac{\text{Lumens}}{\text{constant}}$$

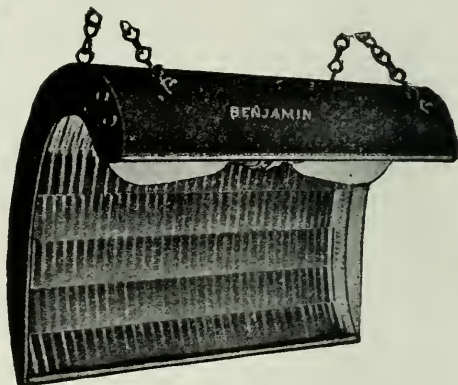
This constant has the value 5. Thus, of a window 10 ft. long by 6 ft. wide by 6 ft. deep, the total area to be illuminated (floor and back) is $60 + 60 = 120$ square feet in all. If the illumination is 10 ft.-candles 1200 lumens are wanted and the

$$\text{corresponding Wattage is } \frac{1200}{5} = 240.$$

Naturally a general formula of this kind intended to be applied to usual conditions would have to be modified slightly in special cases.

The new Benjamin catalogue from which these data are reproduced is a useful and interesting production. The matter is arranged in a concise way, and

many shapes of reflectors are shown. There are several good photographs of installations taken by artificial light. The remainder of the catalogue is devoted to various Benjamin specialities, such as electric motor-horns, friction drive screw-drivers, tool-sets, &c. We understand also that no less than 67,000 of the new "Ezekleen" metal reflectors (which are



"Intensive" shop window reflector.

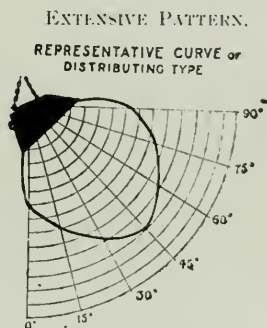
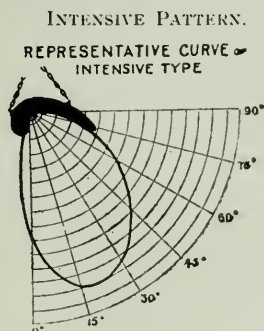
intended to replace the shallow opal reflectors previously made abroad in great numbers) have been supplied to the War Office for use in the huts with Kitchener's armies. Finally, there is a short summary of the requirements of industrial lighting. Also of interest are the new half-watt fittings, on which we hope to say something in a subsequent issue.

THE MANUFACTURE OF THORIA AND CERIA IN ENGLAND.

DURING a recent visit to Mr. G. Harrop at the works of the Plaissetty Manufacturing Co., we were informed that a private company, to be known as the "British Thoria Company," was formed early in October last with a view to supplying the chemicals required in the manufacture of incandescent mantles.

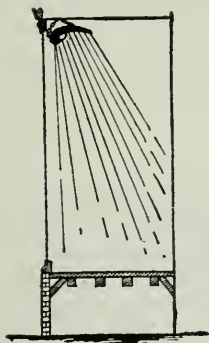
We understand that already considerable quantities of thoria, ceria, and alumina are being made, and that early in the new year the process will be in full swing. The establishment of this new chemical business in England should be of great interest to the British incandescent mantle industries.

BENJAMIN "IMPROVED" SHOP WINDOW REFLECTORS.

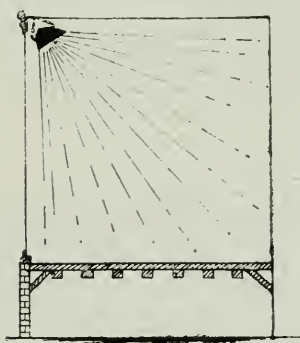


DISTRIBUTION OF LIGHT.

HIGH AND SHALLOW
WINDOW.



HEIGHT AND WIDTH APPROXIMATELY
EQUAL.



TYPICAL SHOP WINDOW INSTALLATIONS CORRESPONDING TO TWO TYPES OF REFLECTORS.

EDISWAN ELECTRICAL PRESENTS.

THIS is the title of a little Ediswan leaflet describing electrical radiators, kettles, adjustable floor standards, &c.—all British made. Our reference to this inevitably occurs after Christmas is past, but no matter. While the damp weather prevails these Ediswan utilities are likely to continue in request.

We may also mention that the Edison and Swan United Electric Light Co., Ltd., have received a contract for next year's supply of Royal Ediswan lamps to the Cunard Steamship Co.

SOME EXAMPLES OF MODERN INTERIOR SHOP LIGHTING.

THROUGH the courtesy of Messrs. Siemens Bros. Dynamo Works, Ltd., we are giving on these two pages some illustrations of typical modern installations in various stores in and around London.

At the present time, when the lighting of shop windows is being so restricted by the precautions of the authorities, it is absolutely essential for the interior lighting of a store to be thoroughly up-to-date.

The three examples we are giving show several distinct methods. Fig. 1 is a curtain department in a large store at Stratford. The department is lighted by Wotan half-watt lamps in semi-indirect fittings. It is well known that half-watt lamps have proved to be very

suitable for use with the semi-indirect system.

Fig. 2 is a millinery department in a large store at Deptford. In this case we have Albalux ceiling fittings. The illumination on the ceiling is slightly uneven, but the floor illumination is stated to be very uniform and the illustration quite bears this out.

The third illustration again shows a different type of unit, namely Holophane reflector bowls. In all cases the intention has been to screen the light source and distribute the light evenly throughout the store. Without these modern lighting methods the organisation of the modern store could not run smoothly. Good lighting is essential to good service.



FIG. 3.—A department at Whiteley's Stores lighted by Wotan lamps in Holophane Reflector Bowls.



FIG. 1.—A large store in Stratford lighted by Wotan half-watt lamps in opal semi-indirect fittings.



FIG. 2.—A large store at Deptford lighted by standard Wotan lamps in Albalux ceiling fittings.

HOLOPHANE GLASSWARE FOR OUTSIDE LIGHTING.

A NEW catalogue just issued by **Holophane Ltd.** describes some entirely new fittings for use with Half-Watt lamps, and designed for street and outside shop lighting. We illustrate some of these types. Fig. 1 shows in section the construction of the glassware which is based on an entirely new principle, prismatic glassware: namely, constructing the globe of two prismatic

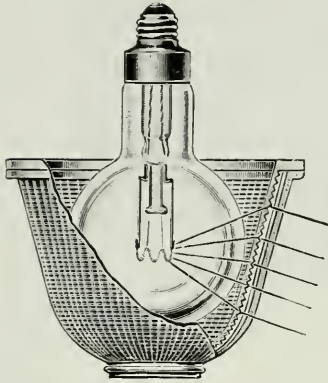


FIG. 1.—Cross section of Holophane Refractor Globe, showing course of rays through the prisms.

elements mounted one inside the other so as to have the desired distributing effect on the light, and yet to present a smooth surface on both sides. By reason of this smoothness the unit is easy to clean and does not accumulate dust. It can hardly be doubted that the mechanical difficulties in producing a unit of this kind are considerable, and to overcome them is a very creditable piece of work.

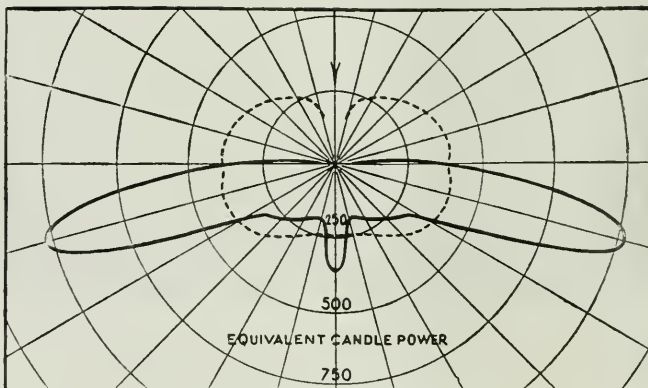
The advantages of the unit are stated to be as follows:—

1. The maximum light is sent out at an angle 15° below the horizontal.
2. The intrinsic brilliancy of the filament is reduced whilst the absorption is practicably negligible.
3. The lamp is weather-protected.
4. The enclosing glass unit allows for ventilation, and not a collector of dirt.
5. The cost of maintenance of the enclosing glass unit is small.
6. The light is distributed evenly over a wide area, as shown by the characteristic polar curve.



FIG. 2.—Typical Fitting.

For street lighting such a unit should be very useful. It achieves the result of securing the desired distribution of light, so as to illuminate the pavement evenly by altering the direction of the rays and without absorbing a considerable proportion of the light. At the same time the diffusion of the light helps to remove glare.



Distribution of Light from above unit.
Lamp alone (shown dotted). Lamp with "Refractor Lantern" (shown full).

THE "ZENDA" HIGH PRESSURE PETROLEUM LAMP.

OF late years the use of high pressure oil lamps with incandescent mantles has considerably extended the applications of this illuminant. We had recently an opportunity of inspecting the "Zenda" lamp which is a Swedish invention adapted to the use of Russian paraffin oil, such as can readily be obtained at all local stores. The standard size of lamp yields 800-1000 candle-power according to type, and it is said that the cost of oil consumption does not amount to more than three-eighths of a penny per hour.

There are two essential parts, the lamp itself and the container for the oil, which are connected by thin copper piping of any desired length.

The container is separated into two compartments: the lower and smaller part where the air is compressed and stored, and the upper part that which holds the oil. The container is charged with two gallons of oil and the pressure is raised by means of a small hand pump to six atmospheres, as shown on a dial. While the lamp is in use, however, the pressure used in the container is maintained constant at two and a half atmospheres by means of a reducing valve. Like other lamps of this kind the Zenda lamp is started by means of a little methylated spirit. When the cock is turned on the oil flows into the vapourising chamber in the lamp, issuing from the same through a small hole in the nipple in the form of hot vapour and mixing freely with the air before entering into the burner. An interesting point to be noticed is that after the lamp has been extinguished the unused oil returns to the container and is used again when the lamp is next lighted. Another point is the special needle for cleaning the nozzle—a process which can be executed without disarranging the lamp.

There is no need for repumping until all the oil in the container has been exhausted, notwithstanding the fact of the lamp being turned out and relighted several times.

It is stated that the lamp can be used equally well for indoor or outdoor lighting, and can be either suspended or mounted on posts or brackets. With the advantages named above it should be of interest to many engineers concerned with illumination.

ACETYLENE AND THE WAR.

THE proceedings of the British Acetylene and Welding Association for December, 1914, contain an interesting article describing the use of acetylene in connection with the war. Hitherto these proceedings have appeared in the form of a special inset in the *Acetylene and Welding Journal*. This issue marks a new departure, namely, the publication of the proceedings of the Association as a separate journal.

It is pointed out that the demand for acetylene apparatus has been very great and manufacturers are working at high pressure. "One wonders," the writer remarks, "what Napoleon would say if he could return to-day to his old battlefields in France and Belgium." One thing that would certainly strike him would be the great part played by light in the military proceedings of to-day. "At Malmaison there is exhibited a portable travelling desk which Napoleon always carried with him in the field. As a part of this desk's equipment the visitor is shown a small reflector candlestick in which there remains the unused part of a tallow candle just as it was left by Napoleon. It was this dim light which illuminated the despatches which won some of his most brilliant victories."

At the present moment acetylene is being widely used for lighting the tents, field hospitals, &c., and in the form of portable searchlights. In the Navy auto-acetylene welding is invaluable for repair purposes, and in the kitchen motor vans, acetylene cooking ranges are frequently used, the gas being supplied from a compact portable generator fixed to the footboard of the van.

OSRAM HALF-WATT LAMPS.

IT is now just about a year since the Osram Half-Watt Lamp was introduced to the British people, so there has been time to examine their practical qualities. Our attention has been drawn to an installation of fourteen 110-volt 500-watt lamps in a large paper mill. It is stated that the average life of these lamps was as high as 1,505 hours and that the candle-power has not diminished appreciably since they were installed.

We understand that Half-Watt lamps are now being made in considerable quantities at the Osram Lamp Works, and a leaflet has recently been issued giving particulars and prices.

ELECTRIC LIGHT FIXTURES.

G.E.C. 1915 CATALOGUE (F SECTION).

THE 14th edition of the above catalogue, recently issued by the General Electric Co., Ltd., is divided into seven sections dealing respectively with pendants, brackets, ceiling fixtures, electroliers, standards, bronzes, and crystal fixtures. Over 100 pages have been added; certain special lines, accessories, glassware, signs, &c., are now issued in a separate catalogue.

The pendant section now includes a special series of direct and semi-indirect fittings ("Dalite" system) some excellent examples of which are illustrated in the view of a showroom at the Company's Head Office.

Crystal fixtures and bronzes are, we think, specially well illustrated, and we notice also several pages given up to the Vase standards. China models of this type of fitting have been quite popular, and the styles executed in real Copeland Ware should be much appreciated.

We are glad to see that the Company, in referring to the various glasses (Superlux, Equiluxo, Holophane, &c.) emphasise the importance of securing maximum efficiency and artistic effect: "in other words, the best light and the most of it."

SHELL-PROOF EDISWAN LAMPS.

THE following is an interesting letter received from a soldier at the front, which illustrates the ability to resist vibration of the Ediswan lamps:—

December 5th, 1914.

Messrs. The Ediswan Electric Light Co.,
London.

DEAR SIRs,

While passing through the town of— which has recently been heavily shelled by the German artillery, we entered a house that had suffered severely. Amongst other things I noticed was one of your lamps still hanging from the ceiling and perfectly intact in every way, and this although almost every other thing in the house had been smashed or ruined in some way.

I write this thinking it may be of interest to your good selves, and remain,

Yours faithfully,

P.S.—Owing to censoring, it is impossible to write you the town in question.

ELECTRICAL FIXTURES.

A Recent Publication by Messrs. Falk, Stadelmann & Co.

MESSRS. FALK, STADELMANN & Co. have just issued an abridged addition of the general list of fixtures. Specimens of characteristic types of fixtures—brackets, lanterns, electroliers, &c.—are shown, and bowl fittings of Holophane, Onyx, and other semi-indirect types are included.

During a recent visit to the showrooms of the Company we had an opportunity of seeing many of the types shown in the catalogue. Readers will recall that these showrooms in Farringdon Road are unique for the fact that fittings for gas, oil, and electricity are all on view, and the area occupied is very large. We were impressed particularly by the series of handsome fittings for oil lamps in which this firm does a very large trade. The arrangement of these large showrooms is excellent in several respects, notably in the subdivision of various styles into separate rooms. There is also an ingenious optical effect by means of which the showrooms appear to open out on to a garden at the back. The lighting of the artificial scenery has quite a life-like effect.

Perhaps the most impressive room is that given up to semi-indirect lighting. Here a series of delightful Onyx, Alabaster, and other decorative bowls are on view, some of them of remarkable size. We should think that some of these handsome fittings would be particularly interesting to architects and might be used to advantage in some public buildings where the existing lighting is capable of improvement.

AN OSRAM NOVELTY.

AN ingenious little advertising device is the "Surprise Envelope" now being circularised by the General Electric Co., Ltd. The envelope is in a sense a Jack-in-the-Box, out of which there leaps, on opening, a soldierly figure created by John Hassel. His helmet is an Osram lamp, his epaulette a tumbler switch, and he is wearing the Order of the Magnet. His extended left hand points to the words:—

"Now, Sir! Are you using Osrams? I flatter myself that they can do more work on less current than any other light troops in the world!"

A leaflet in the envelope gives prices of Osram lamps and bears a reproduction of the Osram Lamp Works where 1,500 British workpeople are constantly employed.

INDEX, January, 1915.

	PAGE
Correspondence—	
Lighting Conditions in Paris in War Time	Prof. A. BLONDEL 27
Shop Lighting in War Time	F. W. WILLCOX 28
Dyers' Hall, Lighting of the	10
Editorial	L. GASTER 1
Illuminating Engineering, Summary of Progress during Past Year	5
Illuminating Engineering Society—	
(FOUNDED IN LONDON 1909).	
Account of Meeting on December 1st, 1914	11
New Members	12
Illuminating Engineering in War Time	L. Gaster 13
<i>Discussion</i> —[F. W. Goodenough—J. W. T. Welsh—F. Bailey—W. J. Liberty— T. E. Ritchie—A. Cunningham—F. W. Willcox—J. Macintyre—C. Bussell— F. C. Tilley]	20
Rating of Lamps in Lumens	12
School Lighting, U.S.A. Committee on	39
Topical and Industrial Section—	
Modern Lighting Fittings in the East	29
Shop Lighting Design—Old Methods and New Methods	30
Benjamin Improved Shop Lighting Reflectors	32
Manufacture of Thoria and Ceria in England	32
Modern Show-Window Lighting	34
A Holophane Unit for Outside Lighting	36
The Zenda High Pressure Petroleum Lamp	37
Electrical Fixtures—An Osram Novelty—New G.E.C. Fixture Catalogue	38
War Time, Lighting in	28

A COMMITTEE ON SCHOOL LIGHTING.

A COMMITTEE on School Lighting has recently been organised in the Illuminating Engineering Society under the chairmanship of M. Luckiesh, Nela Park, Cleveland, Ohio. The object of this Committee is briefly as follows:

To prepare a lecture dealing with the conservation of eyesight of school children to be presented before school authorities. This lecture will include the fundamental principles underlying good and bad natural and artificial lighting, the use of window shades, the colour of walls and ceiling, glare from blackboards, glazed paper and other polished surfaces, and general information on how to use the eyes.

To report on lighting conditions in schools.

To prepare plans and specifications of model class rooms.

To introduce brief courses in lighting

as a part of the home-making and practical physics courses.

To construct a miniature model class room for exhibition purposes.

To prepare a code for school lighting suitable for legislature purposes.

To give general publicity to the importance of good lighting in conserving vision.

The importance of the work of this Committee to the human race is evident when it is considered that there are 18,000,000 pairs of eyes in our public schools daily subjected to the strain of study and the performance of other work equally trying on the eyes.

REVIEW OF THE TECHNICAL PRESS.

(Owing to the pressure of other matter we are holding over the Review of the Technical Press until next issue.—ED.)

Preliminary Announcement.

THE LUMINA BUREAU.

AN ADVISORY BUREAU ON ALL MATTERS CONNECTED WITH ILLUMINATION.

The LUMINA Bureau has been formed to give advice on all matters connected with illumination. It is independent of all trade connections, and is therefore in a position to give unbiased information and to deal impartially with all illuminants.

Each inquiry will be referred to an Expert on the subject.

Among other matters the Bureau is prepared to undertake :—

- (1) The Planning of Lighting Installations for Factories, Offices, Shops, Streets, &c.
- (2) Reporting on the Merits of Schemes of Illumination submitted.
- (3) Advice on the Merits of Patents on Lamps and Lighting Appliances.
- (4) Advice on Ancient Light Cases.
- (5) Arbitration of Disputes on Lighting Installations, &c.
- (6) The Preparation of suitable Literature on all matters of illumination.
- (7) Expert Photography of Installation by Day and Artificial Light.

INQUIRIES TO BE ADDRESSED TO :—

THE LUMINA BUREAU, 32, Victoria Street, LONDON, S.W.

Tel.: VICTORIA 5215.

Natural Photographs by Artificial Light.

SEEING IS BELIEVING—SEE THINGS TRUE!

A Collection of Photographs, taken entirely by Artificial Light, is incomparably the best method of demonstrating your system of lighting to a customer.

Such Photographs are better than any verbal description, and show at a glance what the appearance of an installation will be. The impression of *The Eye* is more vivid and lasting than that of *The Ear*. *A charming picture forms one of the best possible advertisements.*

We are prepared to photograph lighting installations of all kinds, *simply by the artificial light existing in the room and without flashlight or other extraneous aid.* Owing to the wide experience at our disposal we can bring out the chief features and enable all the merits and charms of an installation to be properly seen.

Many of our photographs have appeared in *The Illuminating Engineer*. They show both *the actual conditions of illumination and the lighting units employed*, and will be appreciated by any firm interested in illuminating engineering and lighting appliances.

APPLY FOR PARTICULARS TO:—

The LUMINA Bureau Photographic Dept., 32, Victoria Street, London, S.W.

Tel.: VICTORIA 5215.



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.

32, VICTORIA STREET, LONDON, S.W.

Tel. No. 5215 Victoria.

EDITORIAL.

Searchlights : Their Scientific Development and Practical Applications.

The discussion on searchlights at the last meeting of the Society was a very timely and interesting one. As explained by the Chairman in opening the discussion, the Council had wisely decided that there should be no comment on the arrangements made by the authorities in regard to military matters. The various speakers, therefore, necessarily confined themselves to scientific and practical points of general interest, and refrained from giving specific information on some points on which a great deal might have been said in ordinary circumstances.

Nevertheless, the discussion was most instructive. Searchlights, besides playing an important part in military operations, have a wide field of utility in times of peace, and there is great scope for invention in dealing with the new problems that are constantly arising in this highly technical field of work.

The general impression gathered from the discussion, indeed, is that the subject has been somewhat neglected in the past. The literature is

extremely scanty, and there are many fundamental points on which much difference of opinion is expressed. As in most matters that have to do with illuminating engineering, we find here two sharply-defined aspects, the physical and the physiological. We have to consider, first, the variety of sources now available for searchlights of various kinds. To the electric arc must now be added the oxy-acetylene and oxy-petrol appliances and the half-watt lamp, all of which have possible fields of utility, although the arc lamp naturally gives by far the more powerful light. Moreover, as the contributions of Mr. Eck and Mr. Ritchie showed, even the arc light has not reached its possible limit of efficiency, and the evolution of the new alcohol-cooled type, will be followed with keen interest.

Another entirely different line of research is that of Prof. O. Lummer, of Breslau, who is stated to have obtained an intrinsic brilliancy as much as *twenty-three times* that of an ordinary arc crater, by confining the arc in a chamber where the air is at a pressure of twenty-two atmospheres. The steady temperature of a pure carbon arc at normal atmospheric pressure is given as 4200 deg. absolute. At the higher pressure used by Lummer a temperature of 6090 deg. absolute (which is not far removed from that believed to exist in the sun) is said to have been reached. An interesting point is that special impregnated carbons were used, as ordinary carbon apparently does not lend itself to working under very high pressure. Naturally, at such a temperature as this one would expect a very high luminous efficiency. We await confirmatory researches on Lummer's interesting experiments, and we trust that the matter will be promptly taken up in this country.

Further, in the valuable contribution by Mrs. Ayrton in the present number, it is shown how the choice of carbons and the electrical conditions applied to the arc have an important bearing on its candle-power and steadiness, and it is scarcely necessary to point out that an intermittent flickering arc is highly inconvenient for the observation of distant objects. There are also various precautions to be taken in the manipulation of the arc by the operator—a matter which is dealt with in a very practical fashion by Mr. Trotter in his contribution to the discussion.

But even when we have mentioned the foregoing points we have by no means exhausted the field for study. It is a commonplace among scientific men that before any really systematic researches can be carried out one must be in a position to define accurately and to measure the quantities with which one is dealing. Now the remarks of the various speakers, both manufacturers and those who have independently studied the subject, showed that we are far from having reached finality in this respect. Almost invariably it was admitted that the existing methods of defining the capacities of a searchlight, both as regards range and candle-power, are extremely vague. Prof. Blondel's admirable contribution on this subject will suffice to show the many factors determining range and the need for a scientific method of presentation in preference to vague empirical rules.

As regards the candle-power, we believe that an interchange of opinions among authorities would soon clear up the matter and would lead to an acceptable definition. In any case, it is difficult to see how various appliances can be compared except by their aid; without measurement, how is it possible to determine the degree of any improvement? In research it is the small advance that usually heralds the greater, and it is therefore essential to use methods by which even small indications of possible improvements are recorded.

To reach a decision in regard to specifying range is possibly more difficult on account of the many factors involved, but apparently by no means impracticable. One point on which fuller data would seem to be desirable is the absorption of the atmosphere. Professor Blondel gives a table containing some figures obtained on the coasts of France, and we should like to see similar data obtained in this country. Mr. Paterson, it will be noted, is disposed to think that atmospheric absorption is often confused with quite a different matter, *i.e.*, obstruction of vision by luminous haze, and it is quite possible that many preconceived ideas on the extent of absorption may be wrong. Yet another point that has been persistently discussed for many years is the comparative advantages as regards "penetrating power" of light of various colours. This formed the subject of a long controversy in the early days of the electric searchlight, but, judging from the contradictory views one hears expressed, would seem not to have been completely settled.

Finally, we should like to point out that in addition to the *physical* points mentioned above there are physiological aspects to be considered. The appearance of a distant illuminated object depends on the capabilities of the human eye, its imperfections, and its varying behaviour according to the colour of the light and the brightness of the illumination. Many of these points, therefore, would call for the co-operation of the physicist and the physiologist, and could best be solved through the assistance of the Illuminating Engineering Society.

To sum up, therefore, it appears that there are many points in connection with the theory and practice of searchlights that require investigation, and it would be a good plan if the Illuminating Engineering Society could form a committee to deal with them. Many of the questions involved are of national importance, and such an investigation should receive the sanction and assistance of the authorities.

The utilisation of scientific methods of investigation is an essential element to success, and in the future measures should be taken to ensure that full advantage is taken of our available technical resources. After the war there will doubtless be ample opportunities for the discussion and comparison of the various appliances used by the respective countries. In the meantime we think that the Society has rendered good service by this preliminary discussion, which should stimulate research and lead to the subject being taken up in a more scientific manner.

Street Lighting in War Time.

In our last issue we mentioned that a Committee of the Society had been formed to consider the framing of recommendations on shop-window lighting, so as to enable merchants to comply with the requirements of the authorities, and at the same time to get the best illumination possible in the present circumstances. A series of recommendations has now been drafted and approved by the Council and submitted to the authorities. The recommendations cannot be made public just yet, but we may add that there is every reason to hope that the work of the Society in this direction will be favourably considered, and that in dealing with this technical and difficult subject it will do useful public service.

As the abnormal lighting conditions in London have already lasted for several months, and seem likely to be continued, we think that it would be well worth while to make a similar study of the scientific darkening of the streets. We understand that the Committee of members of the Illuminating Engineering Society which drafted the recommendations on shop lighting, has invited the co-operation of several representatives of the Joint Committee formed to prepare the draft standard specification of street lighting, in order to consider what steps can be taken in this direction. The considerable experience gained in studying the illumination in streets in peace time should be a useful qualification in attacking the peculiar problems that have arisen at the present time.

These problems are essentially technical, and those who have an inner knowledge of the engineering aspects of public lighting can render useful service to the authorities. We are glad to see that the rumoured proposal to extinguish all the lighting of London in the event of the arrival of hostile aircraft, is not to be carried into effect. One can only faintly imagine the consequences of the sudden extinction of the lights in crowded places of entertainment, restaurants, hospitals, asylums, etc., and the plight of pedestrians and vehicles in streets suddenly plunged into total darkness would indeed be unfortunate. The immediate consequences to the gas and electric supply works of a sudden cessation of the entire load would be almost equally embarrassing.

The problem at the present time consists not only in adjusting the lighting to meet the requirements of the authorities as regards military defence, but in doing so in such a manner as to safeguard the public as far as possible from ordinary accidents and to cause a minimum of dislocation to trade and business. We notice that there has been a considerable increase in the number of street accidents during the last four months. It is difficult to trace the extent to which the altered lighting has contributed to this increase, without a close watch on the conditions of lighting at the place and time of each accident, and one should naturally discriminate between the increase of accidents by day and night. If the authorities could arrange for particulars of the lighting conditions to be entered along with the other data regarding each mishap, we feel sure that this step would provide some very useful data for the future.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(A Report presented by the Committee on Progress at the Eighth Annual Convention of the Illuminating Engineering Society (U.S.A.), at Cleveland, Sept. 21-24, 1914; slightly abbreviated.)

(Concluded from page 9.)

Photometry.

Heterochromatic Photometry. — The branch of photometry which seems to have had the most attention during the past year is that involving the measurement of lights of different colour. The continued increase in the temperature at which incandescent lamp filaments are being operated has served to accentuate the difference in colour between these lamps and the carbon lamps used as standards.

The study of the flicker photometer has been continued.⁹⁸ Some recent experiments have been made indicating that the time element in the growth of colour sensations will explain the reason for weighting red light more than blue-green light when comparing the flicker method with the direct comparison method. On the other hand, a comparison, using the two methods, of two lights of the same resultant colour, one having a continuous spectrum the other made up synthetically, gave the same result in both cases.

The method of employing coloured solutions as filters is well known. A

recently described⁹⁹ application consists in the use of two wedge shaped glass cells, one of which contains copper sulphate, ammonia and distilled water, and the other iodine, potassium iodide and water. By properly varying the position of one wedge with respect to the other an infinite number of colour changes can be produced in the light falling on the photometer and coming from the comparison source.

Still another method has been suggested¹⁰⁰ for use in heterochromatic photometry utilizing the extreme sensibility of the peripheral retina to brightness contrast. The apparatus includes a vertical screen with an opening at its centre, a series of rotating measuring disks made up of sectors of grey and black in varying proportions, and a photometer bar.

Methods.—The use of fluorescence as an indicator of spectral radiation¹⁰¹ forms one of the latest additions to the large number of photometric methods. Radiation from the two sources to be compared

⁹⁹ *Sci. et Art de L'éclair*, November, 1914 p. 163.

¹⁰⁰ *Elec. Rev. & W.E.*, March 7, 1914, p. 478.

¹⁰¹ *Zeit. f. Inst.*, November, 1914, p. 348.

⁹⁸ *Elec. World*, May, 1914, p. 1105.

enters opposite sides of a vessel containing a fluorescent solution of known constitution and absorbing qualities. The point at which the intensity of fluorescence is the same is noted on a moving carriage.

The use of ruled gratings for cutting down intensity in photometric work was developed some years ago. A new modification¹⁰² consists in placing one in front of another with their lines parallel. One grating is fixed and the other is movable by means of a graduated screw in a direction perpendicular to the lines. Thus an effective absorption is obtained from 50 per cent. to 0.

Photo-electric Cell.—The search for an objective photometer which shall take the place of the human eye in measuring light intensities continues but with questionable success.

Abroad a recent study of the photo-electric cell for this purpose gave apparently satisfactory results.¹⁰³ Filters were used such that the maximum sensitiveness occurred at the same point in the spectrum as with the human eye. Differences of not more than 6 per cent. were found when measuring the candle-power of various lamps with the cell and with an ordinary photometer.

Another investigation in which an effort was made to use the cell in measurements of sunlight¹⁰⁴ showed that for the measurement of very high intensities, cells of the vacuum type must be used.

The whole question of the practicability of the use of the photo-electric cell in photometry¹⁰⁵ has recently been thrown open, however, in consequence of the results of an investigation of gas-filled cells in this country which seems to show that this cell is not as satisfactory as has been considered. The illumination current relationship, formerly considered linear, is shown to be a highly complicated function of a number of factors.

The results of another investigation¹⁰⁶ indicate that the photo-electric effect of potassium is to be explained by the considerable gas assimilation of this material, i.e., that the existence of gas is

a necessary condition for appreciable photometric effect. The correctness of this conclusion is questioned, however, in consequence of some later measurements¹⁰⁷ on freshly cut sodium surfaces in vessels containing residual gases and in others using an extremely high vacuum.

Selenium.—It has been hoped that the selenium cell might be the solution of objective photometry. But no advances in this direction have been made during the past year.

Some work has been done¹⁰⁸ indicating that selenium as such does not have a characteristic sensibility curve, and that differences in the characteristics of light sensitive selenium are purely the result of different crystal formations.

The effect of adding small quantities of tellurium¹⁰⁹ on the sensibility to light of a selenium cell has been studied. It was found that the presence of from 1 to 7 per cent. of tellurium as an impurity in the selenium made a decided difference in the sensibility curves of the cell to various monochromatic radiations in the visible. This is suggested as a possible explanation of the difference found by various observers in the relative position in the spectrum of the maximum of sensibility.

Spectrophotometry.—In spectrophotometry an improvement on the Brace type has been worked out.¹¹⁰ In the older form changes in intensity on one of the fields were obtained by changing the slit width of the corresponding collimator. To obviate the errors introduced and the elaborate calibration required, polarization has been employed. Two nicol prisms are placed in that one of the collimator tubes the light from which is reflected from the silver strip portion of the dispersing prism. It is claimed that the ordinary difficulties arising from the use of polarization are eliminated.

Standards.—The question of light standards has not been agitated much and but little has been done looking toward the establishment of the ultimate primary standard.

¹⁰² *Jour. f. Gas*, May 16, 1914, p. 457.

¹⁰³ *Elek. Zeit.*, April 30, 1914, p. 504.

¹⁰⁴ *Phys. Zeit.*, June 15, 1914, p. 610.

¹⁰⁵ *Astro. Jour.*, June, 1914, p. 428.

¹⁰⁶ *Ber der Deut. Phys. Gesell.*, No. 2, 1914, p. 117.

¹⁰⁷ *Phys. Rev.*, July 1914, p. 73.

¹⁰⁸ *Phys. Rev.*, July, 1914, p. 48.

¹⁰⁹ *C.R.*, July 6, 1914, p. 41.

¹¹⁰ *Astro. Jour.*, April, 1914, p. 204.

The use of the Hefner lamp¹¹¹ as a standard is comparatively limited in this country, but abroad, particularly in Germany, it enjoys considerable popularity as evidenced by the last report of the Physikalisch Technische Reichsanstalt. During the year 1913, 85 lamps were submitted for test, the total number submitted since the beginning of certification in the year 1893 being 2,079. In addition to the Hefner lamps, 78 carbon lamps were tested for use as photometric standards and 333 metal filament lamps.

At the National Physical Laboratory¹¹² in England the international comparison, through the United States Bureau of Standards, the Laboratoire Centrale in Paris and the Reichsanstalt in Berlin, of high efficiency incandescent lamp standards has been completed. Measurements made at the laboratory after the return of the lamps showed that their candle-power had remained constant enough to ascribe an accuracy of 0.25 per cent. to the results. The ratios obtained were as follows:—

Reichsanstalt	
Nat. Phys. Lab. $\times 0.9$	= 1.00
Bur. of Std.	
Nat. Phys. Lab.	= 0.997
Lab. Cent.	
Nat. Phys. Lab.	= 0.998

In these comparisons a colour difference was entailed corresponding to that between a carbon lamp at low efficiency and a tungsten lamp at 1.25 watts per mean horizontal candle.

A portable electric standard for use in measuring the candle-power of gas¹¹³ employs a 4-volt tungsten lamp at 2 w.p.c. and is based on the property of tungsten of rapidly changing its resistance with change in current. The lamp is made one arm of a Wheatstone Bridge and is brought to its rated candle-power by changing a rheostat until the galvanometer gives zero deflection.

Glarimeter.—Under the head of photometry might be mentioned a new instrument called a glarimeter,¹¹⁴ designed to measure the relative glare or gloss of

paper. It was found by experiment that light reflected at an angle of 57.5 deg. from pieces of glazed white paper, calendered black cardboard, calendered white paper and brown solio paper showed a plane polarization 99 per cent. complete. It is a characteristic of most glass surfaces that light reflected from them at this angle, 57.5 deg., is almost completely plane polarized. The instrument, then, was designed to measure the glare by determining the fraction of the light reflected from the paper at an angle of 57.5 deg. which is polarized, the illumination falling on the paper at approximately this same angle.

An interesting test made with this instrument showed that the effect of passing a sheet of unsized newspaper through the calendering rolls twenty-nine times increased the per cent. glare from 27.7 to 64.8.

Illuminating Engineering Societies.

On the subject of photometric methods the German Illuminating Engineering Society has adopted the following definitions:—¹¹⁵

“Evaluation of sources of light (special lamps excepted). A source of light is to be evaluated through one of three quantities—viz., (1) mean spherical illuminating power (J_o); (2) mean lower hemispherical illuminating power ($J_\circ$); or mean horizontal illuminating power (J_h). Every statement must clearly indicate which of the three quantities is intended.

“From the purely physical standpoint J_o is the most important illuminating power. On practical grounds it is not generally feasible to give up the evaluation of $J_\circ$ or J_h , which has hitherto been customary.

“It is therefore recommended that there should be added to the figures for $J_\circ$ or J_h the factor for their conversion into J_o .”

These definitions have been adopted by the German Association of Gas and Water Engineers and the Institute of German Electrical Engineers.

No conclusions have as yet been reached on the question of nomenclature, but in England the 1910 report of the

¹¹¹ *Jour. f. Gas.*, June 27, 1914, p. 622.

¹¹² *Elec.*, July, 1914, p. 574.

¹¹³ *Proc. Amer. Gas Inst.*, Vol. VIII, 1913, p. 325.

¹¹⁴ *Elec. World*, March 21, 1914, p. 645.

¹¹⁵ *Jour. Gas Lt.*, July 14, 1914, p. 99.

Committee on Nomenclature and Standards of the Illuminating Engineering Society (U.S.) has been made the basis of a considerable discussion. The results of this discussion, which was participated in by members in other countries, show that there is still a wide diversity of opinion on this subject and emphasizes the necessity of such a body as the International Illumination Commission to which problems of this character may be referred.

According to a published statement of Prof. A. Blondel¹¹⁶ the effort to establish an illuminating engineering society in France has not been successful. This is apparently due to inability to obtain the moral support of the two large technical societies, one of gas and one of electricity.

International Illumination Commission.

The most important advance in illuminating engineering as a whole came just before the last convention and was forecasted in last year's report.

At the fourth meeting of the International Photometric Commission¹¹⁷ held in Berlin, August 27th, 1913, a re-organization was effected in which delegates from ten countries participated and formed the International Illumination Commission. The following officers were elected: President, M. Th. Vautier, France; Vice-Presidents, Prof. Hans Bunte, Germany; Dr. E. P. Hyde, America; Dr. L. Kusminsky, Austria; Hon. Secretary, Mr. C. C. Paterson, England; Treasurer, Mr. Weiss, Switzerland. The above officers with two representatives from each contributing country form the executive committee. The representatives of each country are selected by its national committee, if there is one. In default of a national committee societies interested may act directly, but in no case may more than 10 delegates be sent to represent any one country. French was adopted as the basic language.

As a result of this action there is now an authoritative organisation which has for its object the study of questions relative to the lighting industry and the establishment by all appropriate means

of international agreement on questions of illumination and to which may be referred such problems as international agreement on a primary standard of light; uniformity of nomenclature in illuminating engineering; definitions, standard photometric methods, etc.

In accordance with the requirements of the Commission a National Committee has been formed in Great Britain¹¹⁸ composed of five representatives of each of the three technical societies and two from the National Physical Laboratory.

In this country a National Committee had been formed prior to the establishment of the International Commission. It was composed of two representatives from each of the following societies. The Illuminating Engineering Society; The American Gas Institute and the American Institute of Electrical Engineers, while the American Physical Society was informally represented. At a meeting held in February of this year statutes were adopted fixing the membership of the committee as follows: Not more than three representatives from each of the constituent technical societies, one representative from the Bureau of Standards. Any individual who represents the United States as an officer or member of the Executive Committee, or who is a member of any standing committee of the International Commission on Illumination and who is not otherwise a member of the committee. Any individual who actually represented the committee as delegate in attendance at the last preceding meeting of the International Commission on Illumination, and who is not otherwise a member of the committee. Furthermore, when for special reasons the committee desires the intimate co-operation of certain individuals, the committee may elect such individuals as members at large. The terms of all members at large shall expire at the time of the annual November meeting.

Globes, Reflectors and Fixtures.

Since the last report there has been a great increase in the variety of reflecting and diffusing equipment available for lighting. This increase has proceeded along artistic lines, along engineering

¹¹⁶ *Sci. et Art de l'Eclair*, May, 1914, p. 158.

¹¹⁷ *Elc. World*, September 3, 1913, p. 511.

¹¹⁸ *Ill. Eng.* (London), January, 1914, p. 14.

lines, along the lines of special adaptation to particular needs, along the lines of higher and lower priced units and of larger and smaller units.

This increase in variety is particularly noticeable in the semi-indirect field. In selecting units to-day, the selection can be made from a much greater choice than was possible a year ago. There is also a tendency on the part of manufacturers to put out units which approach direct lighting in the results they give, as far as diffusion is concerned, but have the appearance of a semi-indirect lighting unit. This has resulted in the closing of the gap between direct lighting and semi-indirect lighting, as far as reflecting and diffusing equipment is concerned. This emphasizes the need of some other terms than indirect and semi-indirect to apply to lighting systems.

There is a greater tendency in the design of globes and reflectors to have them particularly adapted to architectural needs and particular classes of service. There is a greater variety of units corresponding to particular periods of architecture, and units designed especially for the lighting of churches, hospitals and residences are more in evidence.

From an engineering standpoint the most marked developments during the past year are those involving the use of semi-indirect fixtures for both gas and electric lights and in particular those which have accompanied the advent of the high candle-power and high efficiency gas cluster lamps and the non-vacuum tungsten lamps. The high intensities of these types has made the need for the use of diffusing globes more apparent than ever. In all the units put out for these lamps and the holding equipment for them the ventilation is an important feature and in the case of gas lamps mica sheets are utilized to baffle the heated products horizontally and thereby prevent ceiling discoloration. Mica baffles are also used in gas lamps below the source to prevent over-heating of the glassware. Another point of interest in the tungsten lamp is that the type of filament is much more concentrated than formerly and this is a distinct advantage in that it is possible to obtain higher efficiencies and better distributions of light than were formerly possible with much longer filaments.

In industrial lighting there has been a noticeable tendency in the direction of the increased use of deep bowl reflectors. In street lighting a prismatic refractor has been developed which gives a very extreme distribution of light, the candle-power being highest at about 75 to 80° from the vertically downward direction.

The extent to which the artistic in lamp fixtures has progressed is shown in the production of a dome made of china by a manufacturer of artware and dinner sets.¹¹⁹

Mention was made in last year's report of the use of marble in thin sheets to replace glass in lamp fixtures. A big improvement¹²⁰ in this material is shown in the production of plates $\frac{1}{8}$ in. to $\frac{3}{8}$ in. thick (3 to 20 mm.) polished on both surfaces and impregnated with various oils at high pressure and temperatures. In this connection a recent investigation of this material has shown that it is much more translucent than milk glass. The treated marble was found to transmit more red and much more blue than milk glass and is a good diffusing agent even though having a translucency of 40 per cent. The following table shows the results found on the translucency and diathermancy of these marble sheets as compared with various substances.

TRANSLUCENCY AND DIATHERMACY OF VARIOUS SUBSTANCES.

Thickness and material of interposed stratum.	Percentage of light transmitted.	Percentage of heat transmitted.
None	100	100
Treated marble 0.12 in. (3 mm.)	41	5.1
Untreated marble 0.12 in.	21	4.9
Mica 0.02 in.	33	67.5
Clear glass 0.08 in. (2.2 mm.)	92	80.0
Hard rubber 0.01 in. (0.3 m.)	55	51.7
Writing paper	27.5	4.8
Writing paper oiled	55	16.7
Milk glass 0.12 in.	25	16.6
Ground glass 0.12 in.	76	40.6

A still further extension of the daylight duplication idea¹²¹ is to be found in the development of spectacles made of colored absorbing glass fitted with a dyed film. Different spectacles are designed for different light sources, the materials used being the same as those which would be required

¹¹⁹ *Elec. World*, May 23, 1914, p. 1166.

¹²⁰ *Elek. Zeit.*, February 19, 1914, p. 199.

¹²¹ *Light. Jour.* (U.S.), February, 1914, p. 34.

in order to make an artificial daylight lamp out of the source in question.

Fixtures have also been designed¹²² which give a light distribution in a room similar to that given by a window, thus imitating daylight distribution.

The importance of avoiding glare is being appreciated to such an extent that spectacles using colored glass have been devised for attachment to the visor of a baseball player's cap.¹²³ They are instantaneously adjustable and should be of considerable help to the player when it is found necessary to look directly toward the sun.

Physiology.

The action of radiant energy which enters the eye has been studied,¹²⁴ showing the relative amounts of energy absorbed by the various eye media and how the amount of absorbed energy varies with the temperature of the source. Thus it was found that in the total eye about thirty times as much energy is absorbed per lumen of tungsten light as per lumen of light from a black body at 5,000°.

Some work on visual acuity under monochromatic light¹²⁵ from the middle of the spectrum as compared with ordinary daylight showed considerable advantage in favour of the former. Results were also obtained indicating that yellow-green eye glasses have a marked effect in improving visual acuity in very bright daylight.

The final results of the extended research of the Glass Workers Cataract Committee of the Royal Society,¹²⁶ to find a glass that will cut off as much as possible of the radiation beyond both ends of the visible spectrum and still be transparent to the visible, have been published. Glasses have been prepared that cut off more than 90 per cent. of the heat radiation, are opaque to the ultra-violet and sufficiently free from color to be capable of use as spectacles.

The relative hygienic effects of gas and electricity¹²⁷ when used for lighting purposes has again been made the subject of an investigation. The test room used

was 2 m. high, 1.25 m. long and 0.6 m. wide, and the results have been variously interpreted depending on whether the critic admits that conditions in a chamber of this size are or are not comparable with those in ordinary living rooms. Another more recent investigation¹²⁸ has been made using two rooms of about 57½ cu. m. in size.

Legislation.

Distinct progress in settling a controversy which has been agitated for many years is seen in a recent parliamentary action in England.¹²⁹ The question of whether the quality of gas should be judged on a basis of its calorific or its illuminating power has been for a long time a prolific source of argument and discussion. Charters have been granted recently to two gas companies specifying a calorific standard as a basis for test. Unfortunately there seems to be still a decided difference of opinion as to just how this calorific standard should be specified, but doubtless this will be settled after further research.

In this country the Wisconsin Public Service Commission considered the matter some six years ago, while in New York the question is still under advisement by the New York State Commission, although it has been determined as the result of an extended and very careful series of tests, that there is no definite law between the candle-power and heat unit value of artificial gas. Hence it follows that in changing laws which specify candle-power, it will not be fair to adopt a specific factor to fix the calorific value from the value of luminous intensity.

On the thirteenth of October the results of the work of a commission¹³⁰ appointed to fix the units of heat, light, etc., were submitted to the French Academy of Sciences for recommendation before being put into laws for France. The bougie decimale is proposed for the standard of light and defined in accordance with the recommendations of the International Congress held in Paris in 1889.

Legislation with respect to headlights is mentioned under the latter caption.

¹²² *Light. Jour.* (U.S.), February, 1914, p. 99.

¹²³ *Pop. Mech.*, August, 1914, p. 175.

¹²⁴ *Elec. World*, October 25, 1913, p. 844.

¹²⁵ *Elec. World*, December 6, 1913, p. 1160.

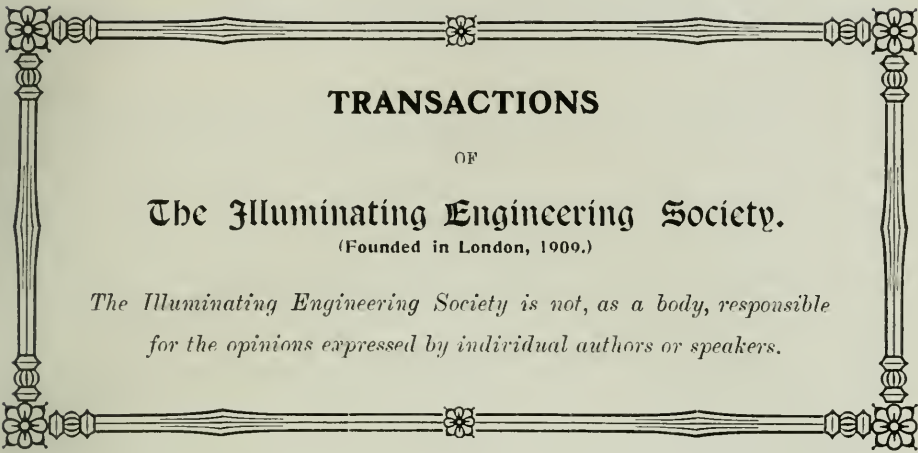
¹²⁶ *Phil. Trans. of the Royal Society*, A 509.

¹²⁷ *Elec.*, May 29, 1914, p. 309.

¹²⁸ *Jour. f. Gas*, July 11, 1914, p. 690.

¹²⁹ *Jour. of Gas Lt.*, June 23, 1914, p. 943.

¹³⁰ *L'Eclaircie*, November 8, 1913, p. 304 ; December 30, 1913, p. 398.



TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

*The Illuminating Engineering Society is not, as a body, responsible
for the opinions expressed by individual authors or speakers.*

SEARCHLIGHTS :

THEIR SCIENTIFIC DEVELOPMENT AND PRACTICAL APPLICATIONS.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, January 19th, 1915.)

A MEETING of the Society was held as stated above, Mr. A. P. Trotter (V.P.) being in the chair.

The minutes of the last meeting having been taken as read, the HON. SECRETARY announced the names of members in the usual way.

The CHAIRMAN, before calling upon Mr. P. G. Ledger to open the discussion, said it was not expedient that there should be any comments on the arrangements of the authorities with respect to the present War. The object of the discussion was to deal with the scientific development and practical applications of searchlights on general lines.

Among those present were both manufacturers and users of searchlights and

it would no doubt be best to hear first particulars of recent improvements, and to discuss their applications afterwards.

The discussion was then opened by Mr. P. G. LEDGER (see p. 53), and the following also took part: Mr. JUSTUS ECK, Mr. W. M. MORDEY, Mr. A. LYON, Mr. T. E. RITCHIE, Mr. F. W. WILLCOX, Mr. L. R. B. PEARCE, Mr. HAROLD SMITH, Mr. S. D. CHALMERS, and Mrs. HERTHA AYRTON.

In conclusion a vote of thanks was passed to Mr. LEDGER for opening the discussion. The CHAIRMAN announced that the next meeting would take place on February 16th, and would be devoted to "Fixture Design in relation to Interior Decoration."

NEW APPLICANTS FOR MEMBERSHIP IN THE SOCIETY.

The names of the following applicants for membership have been duly submitted and approved by the Council, and were read out by the Hon. Secretary for the first time at the General Meeting on December 1st, 1914.*

In addition, the names of the following applicants have been duly submitted and approved by the Council:—

Dickinson, H., <i>M.I.E.E.</i>	City Electrical Engineer, Greenwood, Victoria Park, Wavertree, LIVERPOOL (1).
Eyers, C. F. C.	Chief Gas Examiner for the State of New South Wales, George Street, SYDNEY, Australia (1).
Ledger, P. G., <i>M.I.E.E.</i>	Electrical Engineer, Messrs. Siemens Bros. Dynamo Works, Ltd., Caxton House, Westminster, LONDON, S.W. (1).
Pitman, C. H.	Lighting Engineer (The General Electric Co., Ltd.); 166, Stockwell Park Road, Brixton, LONDON, S.W.
Tye, L. M.	Lighting Engineer (Holophane Ltd.); 11, Watford Villas, Battersea Park, LONDON, S.W. (1).
Wigham, J. C.	Chief Engineer of Edmundson's Electricity Corporation, 11, Tothill Street, Westminster, LONDON, S.W. (1).

* *Illum. Eng.*, Jan. 1915, p. 12.

The Illuminating Engineering Society

(Founded in London, 1909).

NEXT MEETING.

The **next meeting** of the Society will take place at the House of the Royal Society of Arts (18, John Street, Adelphi, London) on **Tuesday, February 16th, 1915, at 8 p.m.**, when a discussion on the **Development and Design of Lighting Fixtures in relation to Architecture and Interior Decoration** will be opened by **Mr. F. W. Thorpe**.

THE EYESIGHT OF SCHOOL CHILDREN.

At a meeting of the Council of the Illuminating Engineering Society in the United States on January 14th, 1915, Mr. M. Luckiesh presented the manuscript of a paper entitled "Safeguarding the Eyesight of Children." This paper, with some seventeen or eighteen slides, is to be used for a lecture on school lighting for presentation at meetings of school authorities throughout the country.

SEARCHLIGHTS :

SOME NOTES ON THEIR SCIENTIFIC DEVELOPMENT AND PRACTICAL APPLICATIONS.

BY P. G. LEDGER.

Introduction to Discussion at the Meeting of Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m., on Tuesday, January 19th, 1915.

A DISTINCTION should be drawn between sources of light intended to serve as *beacons*, i.e. to be visible and to serve as a guide to distant ships, and *searchlights* which are intended to illuminate and reveal distant objects. The former in general utilise a beam of light concentrated over a small angle, the latter may have to be visible over a wide area. The distinction is sharply defined in the case of motor-car headlights and sidelights. In the case of coast lights intermediate conditions exist, since the area to be covered, although considerable compared with that over which a searchlight operates, is often restricted to some extent. In some cases, for example, a travelling concentrated beam may be more efficient than a stationary light of less brilliancy; nevertheless its main function is usually to be seen by vessels rather than to illuminate them.

While searchlights and beacons both presumably come within the scope of this discussion, it is proposed to limit these opening remarks mainly to searchlights. However, there are many optical problems that apply to both.

For the benefit of those to whom such apparatus is unfamiliar I may explain that the searchlight is an apparatus for throwing a beam of light to a considerable distance in order to illuminate distant objects at night, and thus to enable them to be seen. In order to enable the beam to reach the maximum distance, the rays composing it should be approximately parallel to one another, as, if there is much dispersion, the distance that the beam can carry soon diminishes. The projector consists of two main parts, namely, a source of light and a reflector, which latter collects the diffused rays proceeding from the source and projects them forward in a parallel beam.

The chief essential in a searchlight is a source of great intrinsic brilliancy and small dimensions. Strictly a "point-source" would be necessary to get an absolutely parallel beam, but in practice there are few instances in which a beam of smaller divergence than 2 to 3 degrees is desirable. (Otherwise it would take too long to search a given area.)

For searchlights of high power such as are used for maritime work, therefore, the electric arc is invariably used, since its intrinsic brilliancy (estimated at about 200,000 candles per square inch) is incomparably higher than any other artificial illuminant. For motor-car and locomotive headlights bunched incandescent filaments have been used, and it is possible that the half-watt lamp will lead to developments in this direction, and for cinematograph work. There is also the oxy-acetylene incandescent light to be considered. For beacon lighting, on the other hand, where a source of larger dimensions and moderate intrinsic brilliancy is often permissible, incandescent oil and acetylene systems are sometimes used.

In the modern searchlight the beam is obtained merely by placing the arc at the focus of a suitable parabolic mirror. Dispersing prismatic lenses are often provided to be placed in front of the searchlight so as to spread the beam over a wider angle and enable a considerable area to be inspected at close quarters. In the case of coast lights for the guidance of ships at sea such lenses occupy a more important position, and their design is often a matter of considerable complexity according to the functions of the light and the nature of the flashing signals to be provided. The mechanism for regulating the arc presents many interesting features, but does not come within the scope of this discussion.

In the earlier searchlights inclined carbons were used, and this method is still followed in small projectors. Nowadays the carbons are arranged horizontally, the positive carbon carrying the crater facing the mirror. The negative carbon is made as small as possible so as to obstruct a minimum of light, and various devices are used to increase its conductivity (such as coating the exterior with copper and introducing a copper wire into the carbon).

The reflector is a mirror of suitable curvature, that is, a curvature the section of which is a true parabola, and at the focus of this the source of light is placed. (See Fig. 1.) It is a well-known property of all the conic sections—and the parabola is, of course, one of the conics—that the normal at any point bisects the angle between the focal distances of the point. The normal at a point is the straight line perpendicular to the surface at that point illustrated in the diagram by the line PN. Therefore, if a line be drawn from the point F, which is the focus, to the point P on the parabolic surface, and if a normal PN be drawn to the surface at the point P, and, further, if another line PD be drawn from the point P, such that the angle FPN is equal to the angle DPN, then the line PD will proceed in the direction of the other focus of the curve. But, as the other focus is at an infinite distance away, the line PD and all similar lines will be parallel to the axis of the parabola and to one another. Now it is, of course, a property of light when reflected from a surface that the angle of incidence, that is, the angle between the incident ray and the normal, is equal to the angle of reflection, that is, the angle between the reflected ray and the normal. Therefore, if a source of light be placed at the focus F of a parabolic mirror, all rays, such as FP, will proceed, after reflection, in a direction parallel to the axis of the mirror and to each other.

Figs. 2, 3 and 4 serve to show the essentials of a typical searchlight. It consists of a barrel mounted on trunnions with suitable arrangements for turning and tipping. The arc lamp furnishing the source of light is placed inside the barrel, the box containing the mechanism being visible beneath; the leads con-

veying the electric current to the arc lamp can also be seen. The parabolic mirror is placed at the back, and in front is seen a screen made up of parallel strips of plain glass to shut the light in, so that the arc may not be blown out by the wind. On the top of the barrel is a hood for arranging for the ventilation and the passage out of the heated air inside the barrel.

NOTES ON THE HISTORICAL DEVELOPMENTS OF SEARCHLIGHTS.

The history of the searchlight proper does not go back very far, although the use of beacons and coast lights is of early date.

Searchlights of a very elementary character appear to have been used approximately 50 years ago; they were used on French warships in the year 1867, also in the siege of Paris 1870-1871. They appear to have been used by both belligerents. They were, however, of imperfect construction, the mirrors being metallic, which suffered from distortion, corrosion and other defects.

Apparently the first person who made a study of the best means of concentrating the beams of light obtained from an electric arc was a Frenchman, Fresnel, who constructed a special optical apparatus for use in lighthouses. This consisted of a set of concentric prisms, which, acting as a lens, concentrated the light issuing from the luminous point of the heated carbons into a parallel beam. In this case the source of light was behind the lens. Improvements, however, continued to be introduced into the construction of mirrors (where the point of light is in front of the mechanism for concentrating the beam), and more or less complicated methods of approximating to paraboloid surfaces for the reflector were adopted. The reflecting medium, however, was usually silvered glass, as this was found to give more efficient reflection than metallic reflectors.

A simplification in mirror construction was introduced by Mangin, who ground the two surfaces of the mirror to different radii, which had the same effect as a parabolic surface in giving a parallel beam of light. The Mangin mirror had certain disadvantages, however, the principal of which were the liability to

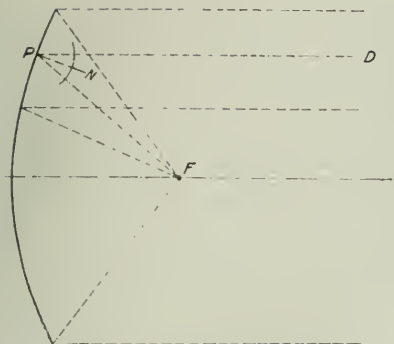


FIG. 1.—Diagram showing characteristic optical properties of parabolic reflecting surface.

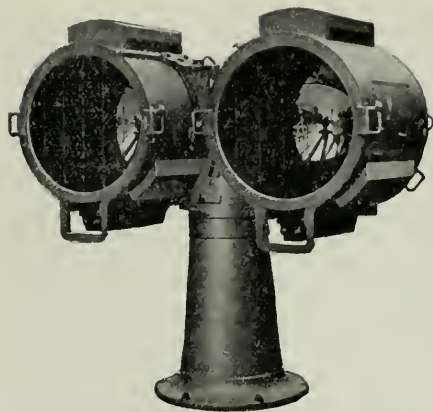


FIG. 3.—Twin Searchlight, 24-inch diam. mirror, 100 ampères.

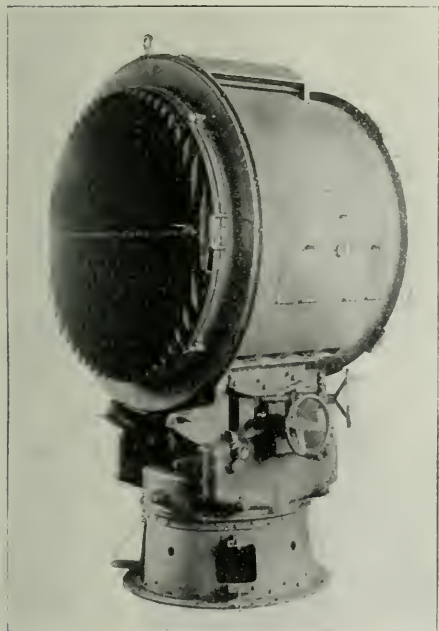


FIG. 2.—Searchlight with special "Venetian blind" signalling shutter; 150 ampères mirror 43 inches (approx.) diameter.

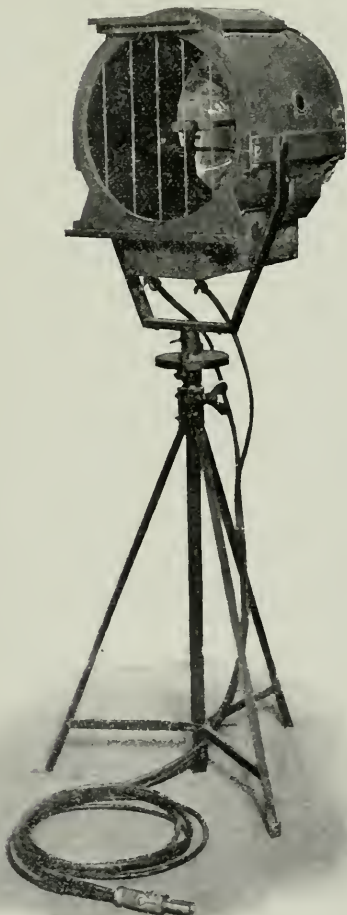


FIG. 4.—Small Stage Searchlight mounted on tripod, 12-inch mirror, 20 ampères.

fracture when heating or cooling owing to the unequal thicknesses of glass, and, for the same reason, was apt to introduce prismatic colours in the edges of the beam. Improvements in grinding machinery, however, have since been made, and there is no difficulty in obtaining parabolically formed mirrors which give parallel beams of great accuracy. The perfection of the mirror is the principal improvement that has been effected in the construction of searchlights.

Reference has already been made to the improvement of using horizontal carbons. Another step has been the introduction of an iris shutter by which the light can be instantaneously and completely shut off so that the searchlight becomes indistinguishable. By the aid of this apparatus the light can be immediately revealed or obstructed, the arc meanwhile continuing to burn normally.

CANDLEPOWER OF SEARCHLIGHTS.

The candlepower given by a powerful searchlight is very difficult to measure. The mere fact that the volume of light is so large gives rise to difficulty, and even the best arc lamps are necessarily less steady than, for instance, the ordinary glow lamp. Fluctuations in the intensity of the light and the colour take place as the carbons are consumed. Tests may be carried out at a distance of 1000 yards or more, the light being merely balanced against a suitable standard on a photometric bench in the usual way. While this may give some indication of the illumination to be derived from a searchlight, in practice the variable absorption of the atmosphere introduces considerable difficulties. Experiments have, however, been made in very clear atmospheres, and these show that the candlepower varies from about 4,000,000 with a projector 40 cms. in diameter and with electrodes using a current of 20 amperes, to as much as 180,000,000 candles with a 150 cm. projector and a current of 150 amperes.

It may be remarked, however, that, apart from the difficulties of measurement, the candlepower of a searchlight is not theoretically such an indefinite quantity as people sometimes suppose. The total flux of light is clearly a definite

physical quantity, and it is only in the case of an absolutely parallel beam (with which one would get the same illumination, except for atmospheric absorption, independent of the distance) that the value to be assigned to the candlepower becomes doubtful. But in practice such a beam is never attained, and even with a divergence so small as 2 to 3 degrees the true centre of the beam can be located at a certain readily calculable distance behind the arc so that the results obtained at distances of 1000 and 2000 yards do not deviate widely from the inverse square law. Naturally, allowance must be made for the true position of the centre of radiation.

The apparently enormous intensities of searchlights are merely a consequence of the light being concentrated in such a very restricted angle far less than would ever be met with in the case of sources used for artificial illumination, even when equipped with a so-called "focusing" reflector. According to data given by Nerz it would appear that a 150 amp. operating at about 9000 watts gives a mean horizontal intensity of about 46,000 candles in the direction of the mirror. The intensification factor of a 150 cm. mirror would be about 4300.

However, for the reasons given above, the candlepower is a very uncertain quantity in practice and is not as a rule specified. The method almost invariably used is to state merely the variety of carbons, the current and voltage at which they will be operated, the diameter and focal length of the mirror.

THE RANGE OF A PROJECTOR.

The "range" of a projector is an even less definite quantity in practice than the candlepower. By this term is usually understood the distance at which objects can be clearly distinguished by its rays, and many of the figures given for the range of modern searchlights are much exaggerated. Manufacturers, recognising the uncertainties introduced by the state of the atmosphere, are averse from giving a definite guarantee on this point. Results obtained in the clear atmosphere of the Mediterranean have proved quite different from those obtained in the mist-laden atmosphere in this country—even on apparently "clear" nights.

One finds also that people have very vague ideas in their mind when they ask for a certain range, frequently demanding that small objects should be visible which could not under any circumstances be seen by the human eye at the distance specified. It is scarcely necessary to say that the size of the object is an important factor. Another equally important point is the contrast between the object and its surroundings and the amount of light reflected from the object itself. An iceberg such as sank the *Titanic*, for example, is very different in this respect from a ship or a rock. If, therefore, any attempt is made to specify range it is necessary to state at least (a) that the atmosphere is absolutely clear, and (b) that an object of a certain size and a certain colour shall be visible at a certain distance.

As a rough guide one might perhaps say that in clear weather, and setting no limit to the size of an object illuminated, a modern 150 amp. searchlight would carry 10,000 yards.

It is of interest to mention that according to Nerz the radius of action of a searchlight is proportional to the square root of the diameter of the mirror and the fourth root of the intrinsic brightness of the source of light. This relation readily enables the carrying power of various searchlights to be compared.

In connection with the range, one may also refer to the angle over which searchlights can operate. Until recently all that was usually required was to sweep the sea horizontally, and even searchlights for general purposes on land were only required to operate through a small vertical angle. But the coming of aircraft has altered these requirements, and it is now necessary that beams of light should be capable of projection vertically upwards. The war has drawn public attention to this matter, but previously the navigation of the air in times of peace had already been much discussed and the erection of luminous signals, so as to indicate to aircraft their whereabouts, had already been undertaken in some countries. The arrangements of flash signalling by coast lights, though only carried out in a horizontal plane, were already sufficiently

complex. To operate such devices in both horizontal and vertical planes would seem a very intricate problem.

As regards the projection of beams of light vertically upwards, there are several distinct methods of achieving this:—

(a) The projector barrel may be given the desired inclination and may be capable of movement both in a vertical and a horizontal plane. (This, however, involves some danger to mirrors, since particles of glowing carbon may fall upon it and damage it.)

(b) Discarding the mirror and replacing it by a lens, in which case the arc could always be below the lens.

(c) Allowing the beam of light to fall on a sufficiently large mirror, inclined at 45° , and capable of rotation in any plane. Although it involves a certain loss of light this would seem to be the most satisfactory method, since the mirror could be readily manipulated so as to direct the beam in any desired direction.

EFFECT OF ATMOSPHERIC ABSORPTION AND COLOUR OF LIGHT.

It has been remarked that the carrying power of searchlights is very largely dependent on the conditions of the atmosphere, and in very foggy weather it is impossible to use them with very great effect.

It is a matter of opinion how far this effect is dependent on the colour of the light. Some people consider that by imparting a little yellow to the beam the object illuminated can be seen more clearly, but other people do not share this view. From a theoretical standpoint it has been suggested that the red end of the spectrum penetrates the atmosphere more easily than the blue end, and that illuminants rich in the red and orange rays have therefore an advantage in this respect.

In searchlights as ordinarily used on land and sea no attempt is made, as a rule, to alter the colour of the light, and apparently one could only do so appreciably by sacrificing some of the existing rays, *i.e.* by colouring the mirror or using a coloured screen in front of the searchlight. In the case of beacons the conditions appear somewhat different, as one is then concerned with the visibility of

distant lights. I believe that sailors and engine drivers consider that a red light can be seen farthest.

RECENT IMPROVEMENTS IN SEARCHLIGHTS.

Improvements in the manufacture of carbons have been introduced from time to time, but without some radical change in principle it hardly seems possible to increase very materially the light from an ordinary searchlight. Apart from improvements in carbons, which may be made to give a crater of greater intrinsic brilliancy, there are of course various losses of light in the existing arrangement, *e.g.* the absorption by the mirror, the obstruction of light by the negative carbon, the fact that a certain amount of light never reaches the mirror. But in most cases it will be found that practical considerations set a limit to any possible changes in this respect. For example, it is inevitable that the arc should be screened in and a certain amount of light strike the barrel. The obstruction of light by the small negative carbon is not a serious matter. Curves are available showing the connection between the specific consumption in candles (horizontal) per watt and the total power given to the arc. It is well known that for the smaller sizes of searchlights there is a considerable gain in efficiency as the power is increased. But as one proceeds from 5-10 kilowatts the gain in efficiency is inconsiderable, and one seems to approach a limit at about 6-7 candles per watt.

On the whole, therefore, any improvement with a view to increasing the light would probably have to be made by increasing the brilliancy of the arc crater. Even here it is necessary that the gain in light should not diminish unduly the life of the carbons—usually about 3-4 hours with the most powerful arcs and as much as 7 hours with certain small projectors.

The steadiness of the arc has been improved by the small diameter of the negative carbon, made possible by the use of a copper core. For a 100 amp. arc the negative would be about 13

millimetres in diameter, and the positive about 27 millimetres, so that the shadow cast by the former—especially with the relatively long arc used in modern searchlights—is inconsiderable. Another device that assists in steadying the arc is the use of a horseshoe of soft iron, which is converted into a magnet by the field of the current flowing through the electrodes. This serves to blow the arc downwards and neutralises the tendency to rise upwards.

The chief recent improvements have been in connection with the general manufacture and control of the searchlight—for example, with a view to increasing rapidity of dismantling and facility for handling the various parts so that they may easily be stowed away on board ship.

Another important improvement has been the control from a distance of the movements of the projector and of the iris shutter (if used). As a general principle it is regarded as desirable that an observer should be some distance away from the searchlight so that his eyes may not be dazzled by the proximity of the beam. Accordingly it is arranged for the officer to carry out observations through a telescope, which is so connected with the projector that the latter follows continuously and instantly all the movements of the telescope.

In conclusion, it is probably safe to say that the greatest interest in projectors, at the present moment at all events, on the part of the general public is centred in their employment for anti-aircraft purposes. We, in London, see every night huge beams of light proceeding from various points and traversing the skies, for the purpose of seeking out any of the enemy's aeroplanes or airships, should they decide to honour us with a visit.

As I believe we have here to-night some experts in the use of projectors for this purpose, I hope that the discussion, when it reaches this phase, will bring out any points of interest in connection with this subject which are not regarded as being of a secret and confidential nature.

SEARCHLIGHTS: THEIR SCIENTIFIC DEVELOPMENT AND PRACTICAL APPLICATIONS.

DISCUSSION.

After Mr. Ledger's opening remarks (see pp. 53-58) THE CHAIRMAN declared the discussion open.

Mr. JUSTUS ECK congratulated the Society on bringing forward such a subject as this, which was naturally of great interest and importance at the present time. Mr. Ledger had said that the searchlight in its present form had practically reached its limit of development—at any rate that was how he read the paper—and the curves he had mentioned seemed to demonstrate that it was impossible to get more candle-power per watt or more effective illumination on the object, even if the current in the searchlights was increased.

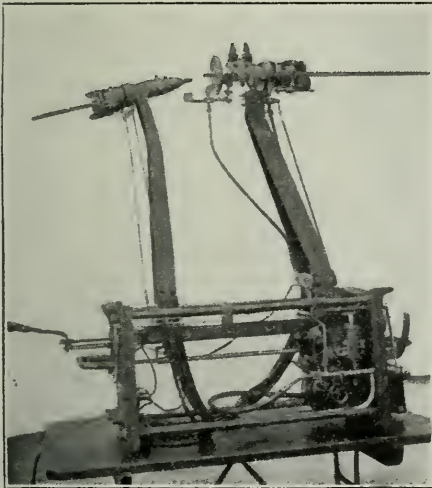


FIG. 1.—Shows arrangement of the small carbons sprayed with alcohol vapour.

This seemed unfortunate, but he thought this was due to the fact that we appeared to have come to the limit of original design in this particular direction.

About a year ago he had the opportunity of seeing the commencement of the developments of a new form of searchlight, which seemed to present many advantages: this had already been described in the American Technical Press, and to some extent it had been mentioned in this country, but it was not referred to by Mr. Ledger. Consequently he had taken the liberty of bringing a few slides, illustrating the new design in its practical form, which showed that the feeding mechanism was similar to that illustrated by Mr. Ledger; but particular attention must be directed to the angle at which the negative carbon approached the horizontal positive carbon: the correct angle had been determined with much care and lengthy experiment. The diameter of the circular carbons was very small, the cross section being about one-fifth of that usually found in searchlights using the same volume

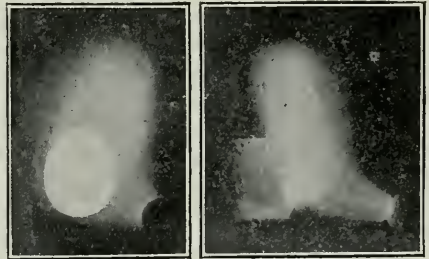


FIG. 2. —Photograph showing nature of crater, and shape of end of carbon.

of current. These carbons were continually rotated, while their points were bathed in the vapour of methylated spirit. In this way much higher specific brilliancy in the crater seemed to be obtained, as well as a more concentrated point of illumination, in a searchlight taking the same current. The vapour

was generated in a little carburettor, heated by the current, placed outside the drum of the searchlight, which was provided with a more powerful ventilating cowl than was usual with ordinary searchlights. A noticeable feature was the entire concentration of the crater on the ends of the carbons, the whole end of the carbons, in fact, being entirely crater.

The polar curve of the lamp was in one plane, similarly shaped to the usual form as given by Nerz, but at the plane at right angle to this was somewhat different, due possibly to the screening by the small negative carbon, or possibly to the passage of the vapour upwards across the face of the crater. The lantern slide (Fig. 3) shows this difference clearly.

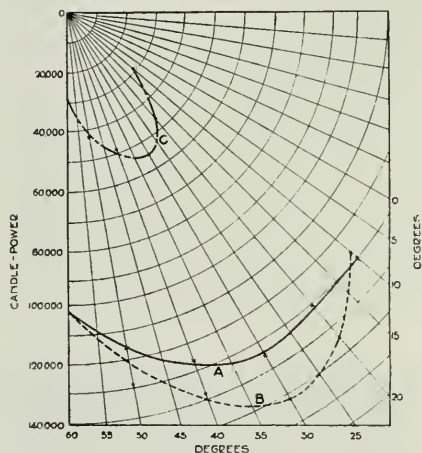


FIG. 3.—Polar Candle-power curves.

Curves A and B show apparent candle-power of lamp with vapour-cooled electrodes. Curve C shows apparent candle-power of lamp with ordinary carbon electrodes.

Current consumption and mirror equipment identical in each case.

Curves A and C taken in one plane and B in another plane at right angles thereto.

In connection with this particular lamp experiments had been undertaken to measure the effective illumination at definite distances. The slide (Fig. 4) shows the measured illumination produced at a distance of 6800 feet from the projector measured along the centre of a field (of 60 minutes of arc radius) the

approximate diameter of which at the distance specified is equivalent to 238 feet.

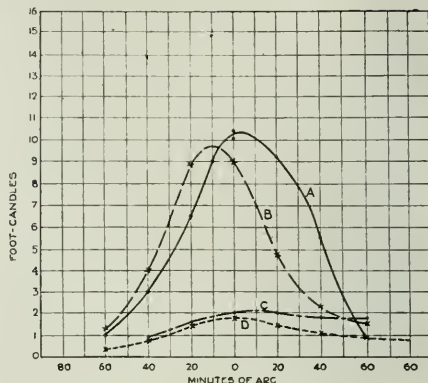


FIG. 4.—Illumination produced at 6,800 feet.

Curves A and B show illumination in foot-candles produced by lamp with vapour-cooled electrodes. Curves C and D that produced by lamp with ordinary carbon electrodes.

Current consumption and mirror equipment identical in each case.

Curves A and C taken in one plane and B and D in another at right angles thereto.

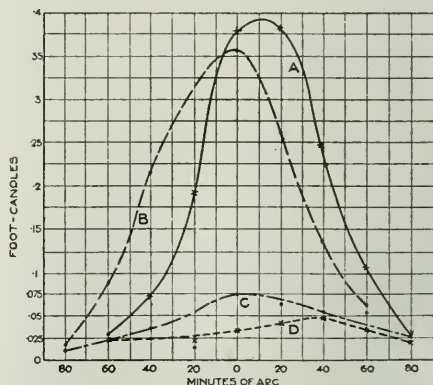


FIG. 5.—Illumination produced at 27,550 feet.

Curves A and B show illumination in foot-candles produced by lamp with vapour-cooled electrodes. Curves C and D that produced by lamp with ordinary carbon electrodes.

Current consumption and mirror equipment identical in each case.

Curves A and C taken in one plane and B and D in another at right angles thereto.

In this case again the measurements are taken with two identical projectors: the curves *a* and *b*, the measurements being taken with the vapour-cooled arc at planes at right angles to one another, and the curves *c* and *d*, with ordinary carbons also in the two planes at right angles one to the other. At this distance the average illumination produced by the vapour-cooled arc is about 5.25 foot-candles, while that produced by the ordinary arc is about 1.25 foot-candles, so that the practical utility of the lamp for observing object is about 4.2 times as great.

In the lantern slide (Fig. 5) results are given with the same lamp under the same conditions, but at a distance of 27,550 feet, or practically the limiting distance suggested by Mr. Ledger in his paper. In this case the diameter of the field at the point of measurement is 1283 feet: the average illumination in the case of the vapour-cooled arc lamp is .185 foot-candles, as compared with the .035 foot-candles of the ordinary arc; in these circumstances the ratio is 5.2 to 1. The increase in this ratio at the greater distance is of interest, and various explanations can be offered.

Mr. W. M. MORDEY said he had been hoping to hear of some radical improvements in searchlights. Mr. Eck had shown how much could be done by comparatively small improvements. Possibly something might result from a consideration of one of the first examples of practical arc lighting in London—the Rapiëff lamps at the *Times* office, in the seventies—followed by the better-known Jablochkoff lighting.

In the Rapiëff lamp—or in one form of it—the carbons, of which there were two pairs, instead of being in the same line, were so placed as to form a “V,” so that both luminous points were more visible and unscreened than with the usual arrangement. It would be interesting to consider whether there would be any advantage in reverting, for searchlight work, to alternating current as used in the Rapiëff lamp and thus obtain equally heated carbons. He appreciated that there would be a serious optical difficulty in getting the light into the focus and that it would necessarily be spread out more. He made experiments

in that direction many years ago with both direct and alternating current, and the general conclusion he came to—he could not recall the actual measurements—was as follows. Not only did the negative carbon screen the light of the positive crater from the mirror but the useful light was further reduced by the loss of the emission from the negative tip which was directed away from the mirror. The highly heated tip of the negative had an area of perhaps one-fifth of that of the crater, and seemed to be nearly or quite as luminous per unit area. It would be interesting to have the results of any tests that have been made on the subject.

The Nerz curve of candle-power per watt for various kilowatts was very interesting, and showed, as one would expect, that the old Admiralty projector of 80—100 amperes with 65 or later with 80 volts was about right.

The author had not referred to the metal mirrors made by Sir Charles Parsons, which he thought were used a great deal, especially on warships supplied to foreign navies. It would be interesting to learn whether that form, which was less liable to injury than glass mirrors, had been successful in practice.

On the question of colour, Mr. Ledger stated that one could only alter the colour of the light by sacrificing some of the existing rays. He would like to know what had been done in the direction of giving the light its colour by mixing in the carbons foreign substances, such as were used for increasing the length of the arc—for example, could salts of strontium be used to give the desirable red tint to which the author referred?

Mr. ARTHUR LYON said the question of candle-power was a very vexed one and commercially a very vital one. Makers were often asked the candle-power of a certain searchlight. He would suggest that if the candle-power of the source were given and also the intensification factor of the mirror, some valuable comparisons could be made. Only that day a man had cabled for the candle-power of a searchlight. He thought the actual light given by the source was referred to, and he cabled back 20,000 candle-power. The answer came

that the customer wanted 2,000,000 candle-power, and seeing at once that he was referring to the projection of the light he guaranteed 37,000,000 candle-power or thereabouts. But what did this information convey?

He wondered whether a unit could not be adopted of a 10 feet square screen at a range of 1,000 yards. Upon this basis data for various ranges at different candle-power could be calculated.

In conclusion, he showed upon the screen a number of slides representing various forms of portable projectors. The first was an oxy-petrol projector

in preference to a mirror, as the beam must be projected vertically or in any plane. To guard against the dropping of ash from the crater of the arc, when the light is directed vertically downwards, a detachable glass is fitted behind the lens, so that any ash falls on the glass and no material damage is done. He agreed that the optical effect was slightly inferior, as there was a certain amount of chromatic aberration, but the light weight and flexibility was a great asset. The weight was only 60 lbs., and the light was about 2,000 intrinsic candle-power.

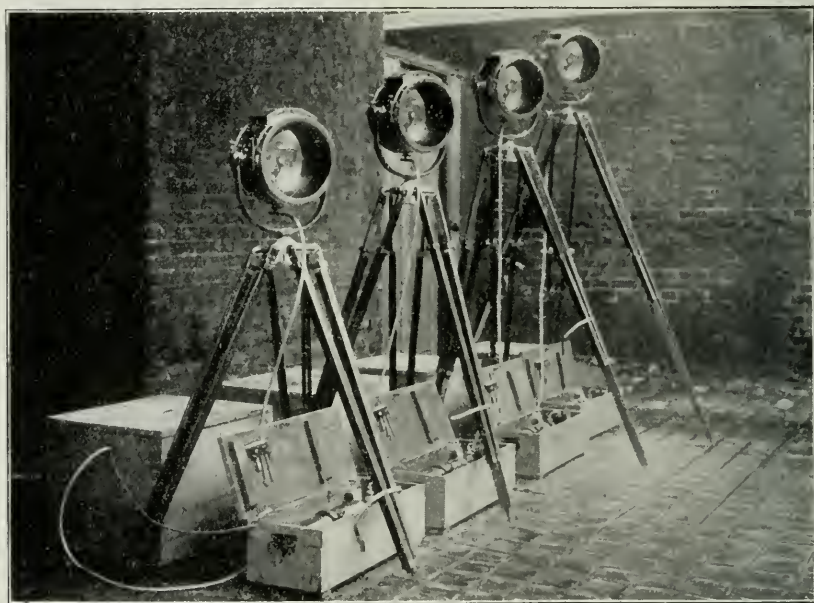


FIG. 1.—Battery of four patent oxy-petrol projectors on tripods complete with transport case for field service. (Mr. A. Lyon.)

on a tripod for army field work (Fig. 1). The range was limited, but its portability was an asset. Another was an aero-arc projector of extra light weight constructed for aeroplane work (Fig. 2). The equipment includes a small dynamo with an automatic field regulating resistance to compensate for the variable speed of the engine. The small projector is fitted with a dioptric or Fresnel lens as referred to by Mr. Ledger: this was adopted

Another slide (Fig. 3) illustrated the Stevens-Lyon field signalling lamp: this utilised small metal filament lamps giving 1.1 or 1.2 candle-power, but had a parabolic mirror and was really a miniature searchlight. It had been possible to read Morse signals with the naked eye at the rate of 17 words a minute at a distance of 11 miles, which was very satisfactory.

The final slide (Figs. 4 and 4a) showed a compound reflector with a lens in front,

of sphero-paraboloid form, used in conjunction with a 12-volt battery and half-watt lamps of 150 candle-power.

This gives a parallel beam, as all rays issuing from the source of light are either reflected or refracted into a concentrated

like standardisation or uniformity even in the most elemental aspects. If one inquired amongst various makers for a 24-inch projector, one was not at all certain of receiving quotations for identical apparatus. Certain people

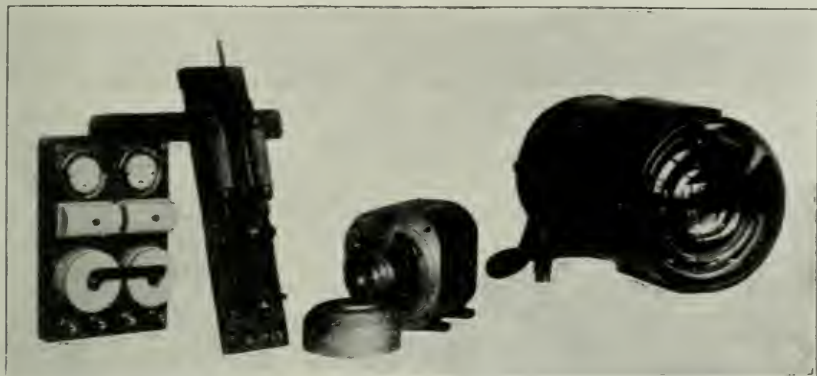


FIG. 2.—Aero-arc projector outfit, with small dynamo and automatic field-regulating resistance. 2,000 candle-power. Weight only 60 lbs. (Mr. A. Lyon.)

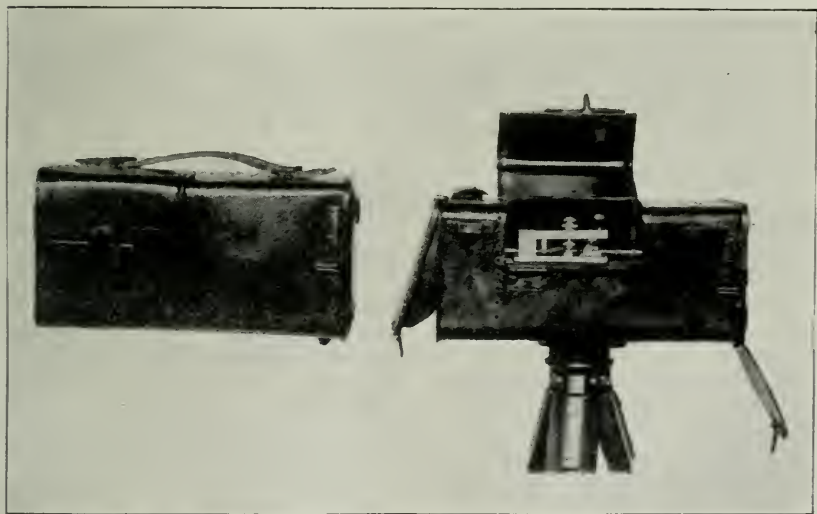


FIG. 3.—Stevens-Lyon patent signalling lamp. (Mr. A. Lyon.)

beam of high efficiency. This lamp has been successfully used for aircraft signalling.

Mr. THOMAS E. RITCHIE welcomed a discussion upon this subject, because we had not yet approached anything

would handle that dimension correctly, *i.e.*, as the diameter of the mirror, but cases were not infrequent of lower prices being put in based upon the 24 inches being taken as the exterior diameter of the barrel, which would enable possibly a 20-inch mirror to be used with a

corresponding saving in the cost of production. The utility of such an equipment would, of course, be considerably less, but that might not be realised until the purchase had been completed.

Then, again, although information was available more or less readily as to carbon dimensions for any given projector, it was exceedingly difficult, if not impossible, to obtain reliable data as

to crater diameters. For these reasons it appeared to him that the Society might add to the good works which it had already accomplished by undertaking, by means of a suitable small committee, the codification of such points. They might, for instance, arrange for the diameter always to be the actual diameter of the mirror, and for the crater diameter to be given, preferably expressed as a fraction of the mirror diameter. Something

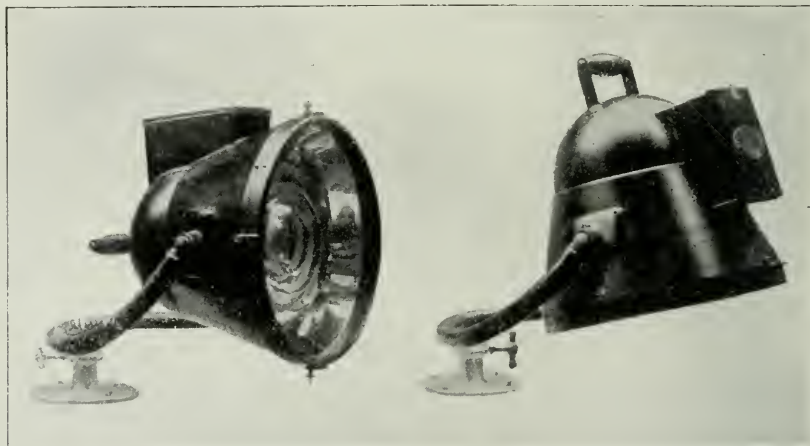


FIG. 4.—Patent electric signalling projectors with sphero-paraboloid reflectors, dioptric lens and Morse key. (*Mr. A. Lyon.*)

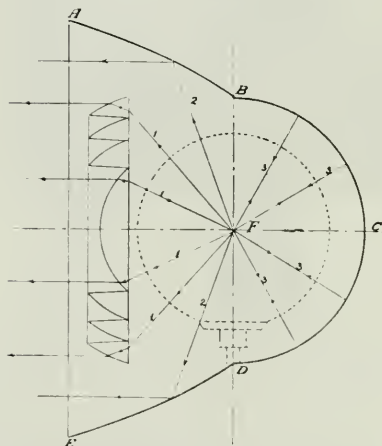


FIG. 4a.—Showing optical system of the signalling projector above. The rays emanating to the right of the focal plane DB return on their own path to the source F and are then collected and refracted by the lens. The rays included in angles AFB, EFD are reflected by the paraboloid surface into a parallel beam of the same axis.

might also be done to encourage greater uniformity in the matter of candle-power ratings, emission and illumination curves, and data of that character.

Turning specifically to the subject matter of the paper, he desired to criticise the use by the author of the data on efficiency, first published by Nerz many years ago, together with his advocacy of range formula, attributable to the same source, which had since been found to be more or less incorrect.

The question of the efficiency of a projector expressed, as in the curve in question, in the candle-power per watt ascertained by dividing the maximum intensity of the rays incident on the mirror by the energy consumption of the are in watts, had, he considered, an important bearing upon Mr. Mordey's remarks on the question of the colour of the beam.

Those conversant with modern practice would, he thought, agree that we could

now do better than the results shown by the curve in question. It was now easily possible to obtain with an increase from 1 to 5 kilowatts in the energy consumption an increase from 4 to $6\frac{1}{2}$ in the candle-power per watt, and with an increase from 5 to 10 kilowatts an increase from $6\frac{1}{2}$ to 7 candle-power per watt. Above this the specific intensity of the crater could not apparently be raised by increase in current alone.

The colour of the projected beam was, he thought, dependent (apart from chemical alteration of the carbons or the use of coloured mirrors or mediums) upon the intensity of the crater, and was, in the case of projectors of normal type, largely influenced by the considerable area of (comparatively) dull red-hot carbon surrounding the crater proper.

Although the beam from such a projector appeared quite white at night, it had been found that when compared with that from a similar projector having carbons of exactly the same quality, but continuously rotated and vapour cooled, it was in reality comparatively yellow. There was, he thought, substantially the same type of change in the colour of the emitted light rays as there was between the carbon filament and the metal filament incandescent lamp, and for much the same reason. It had also been demonstrated that the penetrating value of the beam from vapour-cooled carbon electrodes was distinctly greater.

Tests carried out by the U.S.A. Naval Authorities at Brooklyn had shown that upon the same evening, at the same hour, and therefore under as nearly as possible precisely similar atmospheric and other conditions, it was possible to pick out and hit a target at night at a very much greater distance and considerably more easily than with projectors similar in size and capacity of the ordinary type.

The exact distance varied with the target used and might not be stated. It was, however, of the order of from three to four miles. The height of the observation point might not be given, but was not abnormal.

Other advantages accruing from the use of the small diameter rotating carbon were the practical elimination of troubles due to "wandering" of the arc and

"building" of the carbons; the fact that difficulties incidental to certain impregnating and other processes involved in the manufacture of high-grade carbons could be more successfully overcome in the case of those of small diameter the quality of which was therefore usually higher; the possibility, owing to the more complete combustion at the higher temperature, of varying the colour of the beam by the more successful use of either homogeneously impregnated, or chemically, or metal, cored, or coated, carbons; and, in the case of high angle work—as in searching for aircraft—the considerably reduced risk of the mirror being damaged by the falling from the crater of fragments of white hot carbon.

The author had also referred to the question of glare in its relation to the use of searchlights, and had quite rightly mentioned that with the ordinary type of projector of from 80—150 amperes it was necessary for the observer to be at least 20—30 feet away, otherwise it was not possible to obtain anything like good visibility. This was a point of considerable moment, as the trouble was one very difficult to overcome. Although the beam from such a projector appeared at a distance of a few feet from the front glass to stand out very clearly, a handful of sand thrown into the air showed that the rays of light extended over a very large radius outside the beam proper, and it was undoubtedly those rays which were responsible for the experience of glare from which the operators of such projectors usually suffered.

This defect with the average projector was, of course, well known to the U.S.A. Naval Officials, and it was, therefore, worthy of note that they should have found that with the vapour-cooled projector the absence of this glare was one of the noticeable effects, and that the man actually operating the searchlight could himself pick out and see an object very much farther away than with the average projector, whilst the observer could get within about eight or ten feet of the projector itself. This would be particularly desirable in heavy weather, because the observer and the operator would then be within speaking, or at

any rate hailing, distance the whole time, an advantage which naval men at all events would readily appreciate.

Further points upon which the author had not touched were the influence of vibration and concussion. In both these cases the smaller and more intense crater was an advantage. The flickering, as observed in the projected beam, was very markedly less, and it was thought that to this fact, coupled with the markedly diminished glare or "scattering," was largely due the increased visibility which was obtained.

As regarded concussion, it was well known that with the average projector, if mounted aboard ship, breaking of the arc occurred every time a gun was fired. In a group of ships those not firing at the moment could keep the object under observation, but in the case of a single vessel the breaking of the arc might afford an agile enemy an opportunity of escaping.

With the vapour-cooled projector such arc breakage did not take place, the projector having under test actually withstood a broadside fired from a Dreadnought without breaking arc.

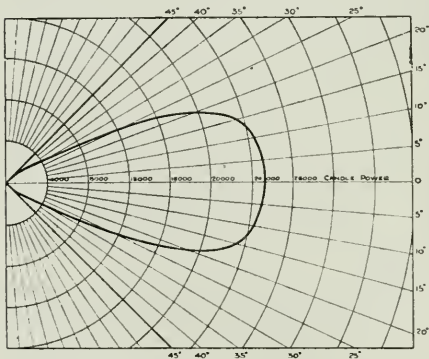


FIG. 1.—Polar Candle-power Curve. Showing apparent candle-power of searchlight projector for aeronautical, fire brigade, and mining rescue work. Note the wide angle of dispersion.

Mr. Ritchie concluded by showing a number of slides. The first (Fig. 1) was the polar curve of a small projector, taking a current of 25 amperes and operating at an arc voltage of 45 volts, which was specially suitable for aeronautical, fire brigade, and mining rescue

work. The feature of this was, he said, the very wide angle of dispersion obtainable, which was of very great value for the purposes for which the lamp was designed.

The next slide (Fig. 2) illustrated a method of testing which enabled one to obtain reliable photographic data as to the character of beam produced under any given conditions, and by means of which, coupled with one or more "receiving" stations, one could also secure definite illumination measurements and so know exactly what one was in a position to offer. Such testing stations also enabled one to investigate closely such problems as that of atmospheric absorption, the effect of mist in the scattering of the light, &c., &c.

The final two slides (Figs. 3 and 4) showed the appearance of the projector, which was removable from its stand, which also folded and could be packed away into quite a small space. Such projectors had, he stated, been successfully used for fire brigade work for several years, and were now beginning to be employed for mining rescue work.

Mr. F. W. WILLCOX presented a table, as shown on p. 68, giving some values obtained with metal filament lamps when used in searchlights of smaller ranges. Metal filament lamps with concentrated filaments, by reason of their advantages of simplicity and adaptability, have an increasing field of use in connection with all kinds of searchlights for amperes below 20 to 10 and have been largely used in locomotive headlights—especially in America. They are also used on motor boats, yachts, tramcars, automobiles and aeroplanes. Searchlights using metal lamps are also employed, as Mr. Ritchie had said, by fire brigades at night, and also for advertising work—for the "flood lighting" of buildings and of hoardings at night. The filaments of these lamps are made in a concentrated form of spiral, and they are replacing, in a large measure, searchlight arcs in sizes below 10 to 20 amperes. Certainly very much better results had been obtained with these metal filament lamps on locomotive headlights than with small power arcs, and the introduction of the "half-watt" lamp has greatly promoted the value and



FIG. 3.—Exterior view showing method of attaching connecting plug and flexible.



FIG. 4.—Exterior view of projector showing remarkable dispersing lens.



FIG. 2.—Showing testing station on roof (sending end). (Mr. T. E. Ritchie.)

application of metal lamps for searchlights.

The table presented herewith gives some interesting data and information upon which inquiries are frequently made in connection with searchlights. Customers often ask how far a searchlight will enable a man to pick up or observe an

column in the table gives data on this interesting question.

The candle-power of the headlight is frequently asked for. This may be the maximum beam candle-power or the average beam candle-power over a certain spread. The table answers these questions in columns 4 and 6.

VALUES WITH SEARCHLIGHTS EMPLOYING METAL FILAMENT LAMPS—CONCENTRATED FILAMENTS.

Type of Headlight.*		Particulars of Lamps.	Maximum Beam c.p.	Spread to 10 per cent. maximum intensity.	Average Beam c.p. (across horizontal diameter of beam) over spread to 10 per cent. of maximum intensity.	Maximum pick-up distance. Man in dark clothes.	Multiplying Factor.
Diam.	Focus.						
9 $\frac{5}{16}$ "	2 $\frac{1}{2}$ "	6 volt 108 watt G-30 Headlight ..	900,000	5 deg.	492,000	2870	6000
		34 volt 250 watt G-30 Headlight ..	300,000	8 deg.	165,000	1820	840
		110 volt 500 watt G-40 Stereopticon ..	700,000	9 deg.	355,000	2500	980
16"	3"	6 volts 72 watts G-25 Headlight ..	550,000	5 deg.	270,000	2290	5240
		34 volt 100 watt G-25 Headlight ..	100,000	8 deg.	55,000	1200	800
		34 volt 250 watt G-30 Headlight ..	250,000	8 deg.	137,000	1700	700
		110 volt 250 watt G-30 Stereopticon ..	225,000	8 deg.	129,000	1760	721
		110 volt 500 watt G-40 Stereopticon ..	650,000	8 deg.	379,000	2460	630
12 $\frac{7}{8}$ "	3"	6 volt 72 watt G-25 Headlight ..	325,000	5 deg.	175,000	1860	3090
		34 volt 100 watt G-25 Headlight ..	60,000	8 deg.	33,000	977	480
		34 volt 250 watt G-30 Headlight ..	150,000	8 deg.	82,000	1410	420
		110 volt 100 watt G-30 Stereopticon ..	27,000	8 deg.	15,000	708	337
		110 volt 250 watt G-30 Stereopticon ..	125,000	8 deg.	69,000	1305	400
12 $\frac{7}{8}$ "	1 $\frac{3}{8}$ "	6 volt 36 watt G-18 $\frac{1}{2}$ Headlight ..	126,000	3 $\frac{1}{2}$ deg.	68,000	1310	2520

* Furnished with Polished Aluminium or Silver-plated Brass Reflector.

obstacle. The answer to this question depends on a great many conditions such as the contrast between the object and the background. For example, a man dressed in white can be seen against a dark background 1.7 times as far as one dressed in medium-coloured clothes, and the latter in turn can be picked up 1.3 times as far as one dressed in dark clothes. The condition of the atmosphere affects the "pick-up" distance, as does also the colour of the light. Next to the last

The last column in the table gives the multiplying factor, which term is frequently used in headlight specifications, and gives the ratio between the candle-power of the light source itself and the candle-power of the resultant beam. An important factor, taking the relative spread and intensity of the resultant beam, is the concentration of the light source at the focal point of the reflector. A concentrated light source out of focus may be just as bad as one having little or

no concentration. In order to show the enormous effect on the beam produced by proper and improper focussing, the following diagram (Fig. 1) is presented.

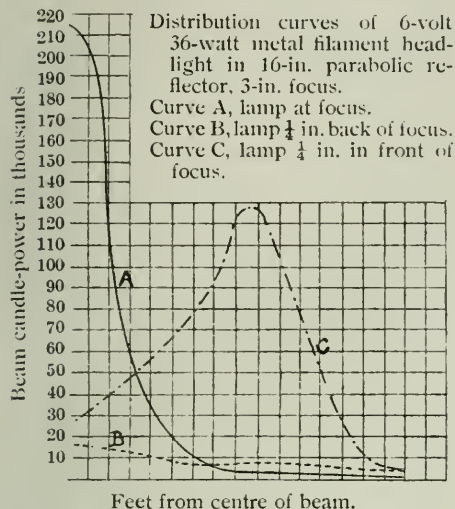


Fig. 1—Searchlights with Metal Filament lamps Showing effects of proper and improper focussing of lamps.



FIG. 2.—Incandescent electric lamp mounted in searchlight.

Here we have the difference between 215,000 maximum beam candle-power (Curve A) when the lamp is in focus as compared to 17,000 candle-power (Curve B) when the lamp is $\frac{1}{4}$ in. rear of its proper focussing position. It is very important therefore that headlights employing metal filament lamps should permit adjustment

so as to secure accurate focussing, which should be always done with each installation of lamps with extreme care to obtain the maximum effect.

Mr. L. R. B. PEARCE remarked that it was not quite accurate to say that with the Siemens twin arc lamp it was possible to train each lamp independently, to sweep in one direction with one and in another direction with the other. As a matter of fact the sweeping movement was comparatively limited, taking the lamps separately; but taking the two together, of course an entire circle could be swept. Reference had been made to the use of metallic salts, such as salts of strontium and calcium. He did not know whether that would be useful; it occurred to him that such ingredients might affect the resistance of the electrode, cause "spurting," and injure the surface of the mirror unless very carefully mixed.

Another speaker referred to the use, by the French Government, of small voltage metal filament lamps which were overrun to the extent of over 100 per cent., enabling a very brilliant light from a comparatively small source to be obtained.

It would be interesting to know whether an advantage in definition could not be obtained by concentrating several searchlights from different directions on the same object. Would it be possible to increase the range in this way?

Mr. H. SMITH referred to the report of a complete series of tests on searchlights and their carbons made by an American officer, Captain J. C. Ohnstad, of the U.S.A. Coast Artillery Corps. The report is given *in extenso* in the September, 1914, number of the *Journal of the United States Artillery*. The Americans give great attention to coast defence, probably more than any other nation, and their experience with large searchlights is therefore very considerable.

The CHAIRMAN said that a message had been received on the telephone that all officers of the Admiralty attending the lecture were desired to leave at once for their respective stations.

Mr. SMITH, continuing, said the officer in question was instructed to experiment with the existing naval searchlights, sizes 24", 30", 36" and 60", and to make tests relevant to the selection of carbons and to convenience in working. He found that by attention to the nature of the carbons the efficiency could be increased by quite 50 per cent., giving in this connection many interesting results and curves. As the carbons burnt, both of them approximated to definite shapes, and the nature of these vitally affected the efficiency of the searchlight. The shapes which best suited the normal type of reflector, which subtends 120° at the arc, were quite definite; the positive should be roughly speaking as basin-shaped, and the negative as pointed as possible. With such shapes the zone of maximum brightness is moved from the usual position at 40° from the axis fully ten degrees further out, giving the maximum light emission to the outer annuli of the mirror, which occupy most of its area. This efficient working on the outer part of the mirror is a counterpart of the optical advantage of the Mangin contrasted with a spherical mirror.

In view of the importance of a suitable form of crater, Captain Ohnstad recommends that the carbons should be manufactured moulded to the correct forms, thus obviating the initial inefficient period during which they burnt to shape. In his complete specification for searchlight carbons he includes full dimensions of the shapes recommended.

The use of special carbons, emitting light which would more readily pierce a misty atmosphere, was found inadvisable. In practice the flame thereby produced obscured the incandescent crater, markedly decreasing the optical efficiency, while the emanations fouled the mirror surface, and caused headaches to the operators in the searchlight casements.

The HON. ASST. SECRETARY then presented a communication received from Prof. A. Blondel (of Paris). (See p. 85.)

He explained that this communication dealt with the determination of the range of searchlights, which depended on a great variety of factors. It was

necessary to consider both the physical factors (candle-power of searchlight, nature and colour of object, atmospheric absorption) and also the physiological factors (Fechner's law, acuteness of vision of observer, aid by field glasses, &c.). Prof. Blondel had worked out relations in great detail, connecting these various quantities.

Mr. S. D. CHALMERS: The question of the range of a searchlight is a very difficult one, principally because the range depends so much on the atmospheric conditions. But it is possible to compare the range of two searchlights under identical conditions. The formula quoted by Nerz is, however, incorrect. He says that the range is directly proportional to the square root of the diameter of the mirror and to the fourth root of the brilliancy of the source of light.

This relation would be true if the aim of the searchlight were to pick up a small minute object which would not subtend an appreciable angle at the eye. But in practice the objects are larger and we wish to identify objects on which the detail can be seen by the eye.

In this case objects which subtend the same angle at the eye and are equally illuminated can be seen equally well, whatever be the observer's distance if we can ignore the absorption of the atmosphere. The range is proportional to the diameter of the mirror and to the square root of the brilliancy of the source of light.

Even when the detail to be seen is smaller this law will hold good if the observer be provided with a telescope of suitable magnification and so designed that the maximum illumination of the image is secured.

The theoretical value of the range may be readily calculated from its constructional data. The intrinsic value of the source is about 16,000 candles per sq. cm. and the mirror behaves as if it were of the same intensity as the source. The illumination due to a mirror of radius a cms. at a distance d metres is:—

$$\frac{16,000 \times \pi \times (a)^2}{d^2} \text{ metre-candles}$$

to see detail of 1 minute an illumination of

1.5 metre-candles is necessary, and a factor of about $\frac{1}{2}$ is required to allow for the loss of light due to reflection and other losses. Thus:—

$$8000 \times \pi \times \frac{(75)^2}{d^2} = 1.5$$

where d is in metres.

$$d^2 = 8000 \times \frac{\pi}{1.5} \times (75)^2$$

$$= 1600 \times \frac{10\pi}{3} \times (75)^2$$

$$= 3000 \times \sqrt{\frac{10}{3}\pi}$$

$$= 9600 \text{ metres approx.}$$

This is curiously near the 10,000 yards which is quoted in the paper as the maximum range.

In recent years progress in the optical design has been rather in the direction of decreasing the focal length for the same aperture. Although this does not increase the candle-power of the searchlight or its range, it is of use in sweeping for an object. The wider the beam, provided the intensity were maintained, the easier would it be for the eye to recognise objects in the unfamiliar aspects they presented when lit up by a searchlight. As the beam sweeps over the object the eye fails to appreciate what is being seen, but if time were given the eye could correct the first impression and the object might be recognised.

Mrs. HERTHA AYRTON and The CHAIRMAN (Mr. A. P. Trotter) then took part in the discussion.*

Mrs. Ayrton's valuable contribution dealt, among other points, with the conditions affecting the steadiness and candle-power of searchlights and the choice of suitable carbons.

Mr. Trotter recalled that he had taken an interest in searchlights since 1884, when he earned his first £5 note by doing some work for the Royal Engineers Committee in connection with projectors for fortress work. In 1900 he had the pleasure and honour of belonging to the Electrical Engineers Volunteers, and the principal work was searchlights.

* The remarks of the Chairman and Mrs. Ayrton have been extended and will be found in the form of special communications on pages 78-86.

Mr. LEDGER said that his remarks were only an introduction to the discussion, and he was glad that they had led to such useful contributions. It had been very interesting to hear about vapour-cooled arc lamps, and he hoped some further information about that would be published in the Journal. He also hoped that in the printed account of the discussion Mrs. Ayrton would be able to let them have the full benefit of her experience.

Mr. C. C. PATERSON was present at the meeting but was obliged to leave early, and has therefore sent in his remarks in writing as follows:—

I quite agree with the author in the contention which he makes that there is essentially no difficulty in rating searchlights, if it is desired to do so, in terms of candle-power. It may be satisfactory for general purposes to define them in terms of the current in the arc and the size of the mirror, but such a rating is not very scientific. One often hears the contention that it is erroneous to speak of the candle-power of searchlights or motor headlights, or similar sources of light emitting a relatively narrow beam. Such a contention, however, will be found to rest on the lack of appreciation of the practical conditions under which such sources of light operate. The beam from a searchlight or a motor headlight is always divergent, and the illumination in such a beam will fall off very nearly according to the inverse square of the distance from the source. Even a searchlight with 2° divergence will be found in practice to follow this rule very closely at all distances from the lamp at which measurements are practicable. I do not think it is quite correct to speak of the candle-power of a searchlight, and I prefer to use the expression "equivalent candle-power," meaning, of course, by this, the candle-power of a lamp which would produce the same illumination at a given distance if put in the place of the searchlight. I do not, however, agree with the author that it is easy to calculate the theoretical point from which the rays from the searchlight appear to emanate, and there is, I think, no justification for tracing back the divergent beam cutting

the outside diameter of the mirror until it comes to a point in the axis, and regarding this point as the virtual centre from which the light radiates.

I should have liked to have discussed at length the question of "Visibility" of objects illuminated by searchlights, but as I am to initiate a discussion on this subject before the end of the session I will reserve until then anything I should otherwise have said on this phase of the question. I would merely remark now that atmospheric absorption is often made responsible for loss of efficiency of searchlights, when what is meant is not I think, absorption at all. Experiments which I have made in conjunction with Mr. Dudding, have shown that on nights which would ordinarily be called fairly clear the atmospheric absorption at a distance of a mile or two miles is relatively little. The difficulty of seeing with searchlights is, of course, that small particles in the atmosphere become brilliantly illuminated, especially in the portion of the beam near to the lamp itself and even when the observer is a little distance from the lamp the trouble does not disappear. These particles become so bright in comparison with the object to be observed two miles away that the eye is dazzled. It is, therefore, merely a question of "glare," and is a kindred phenomenon to that which exists when one tries to read a faintly-illuminated placard with a bright light in one's eyes. It is hardly correct, however, to attribute this lack of ability to see to atmospheric absorption. It is possible that at distances greater than two miles atmospheric absorption may come in to some extent, but the effect will, I think, be found exceedingly small compared with that due to glare.

Mr. J. S. Dow (*communicated*):—

The question of the effect of light of different colours, on which little has been said, is a complicated one. It is generally agreed that the red end of the spectrum penetrates the atmosphere best, but, as the proportion of red rays in an incandescent illuminant is small, this will rarely be a very important factor in the case of searchlights. In the case of beacons, where the visibility of distant luminous points comes in, it might be

more important; and if by any means we could get an illuminant of sufficient intrinsic brilliancy producing only orange-red rays *and no others*, it might be more important still.

But there are other factors that seem to favour the use of this end of the spectrum. In the first place the blue and violet rays, owing to their small penetration, are scattered by the atmosphere to some extent. It is said that the luminous haze so produced is distinctly inconvenient to an observer anywhere near the searchlight; it might be less so if the observer is a long way from it.

However, it is probable that a considerable proportion of the rays from the blue end of the spectrum do reach the object illuminated, and this gives rise to yet another effect. Owing to the human eye not being achromatic, most people cannot focus distant blue rays at all sharply. (An experiment described by the late Mr. Shelford Bidwell was as follows: A line spectrum is thrown on the screen; then, as the observer walks away, the spectrum appears to open out like a fan at the violet end, and some divergence is evident right back to the green.) This fact was alluded to by the author in an article in this journal some years ago.* The effect is to cause a slight haze round distant objects, and the blue rays giving rise to this blurred effect may be actually prejudicial. The definition may be improved if they are blocked out altogether.

The easiest way to obscure such rays in a searchlight would be to tint the glass shutter in front of it slightly yellow. It is possible that this would give rise to a distinct gain in visual acuity.

Mr. H. H. JOHNSON (*communicated*):— This Society is to be congratulated in bringing forward for discussion such an important subject as Searchlight Projectors: it is difficult to find any other electrical plant or apparatus where so much contention exists concerning the specified requirements and the results actually obtained.

* The effect of light of different colours on acuteness of vision. *Illum. Eng.* (Lond.), Vol. II., 1909, p. 233.

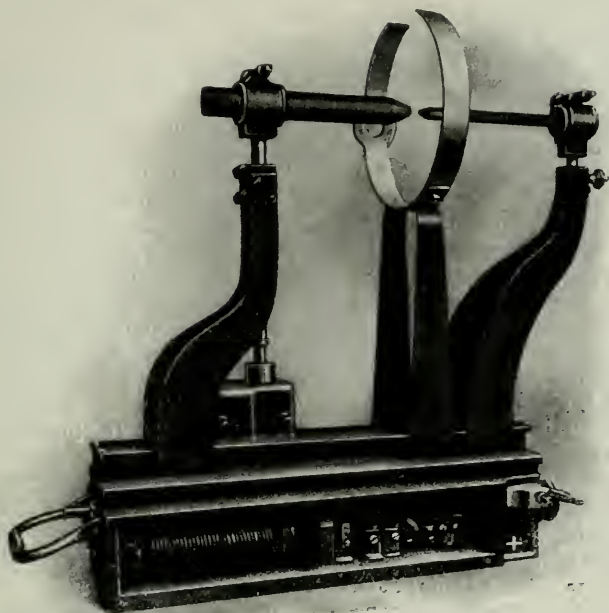


FIG. 1.—Standard horizontal hand and automatic projector lamp of the "Crompton" solenoid type, with an iron deflector fitted to keep the arc central. (*Mr. H. H. Johnson.*)

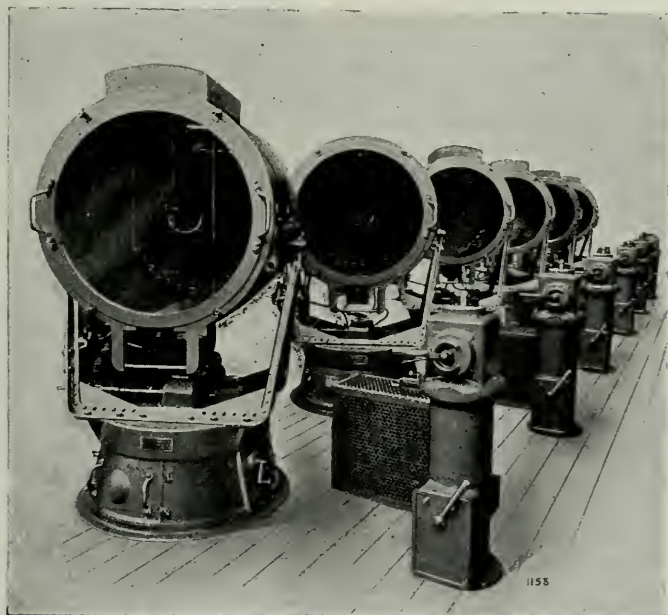


FIG. 2.—Group of 36-in. diameter projectors electrically controlled from a distance, the operating motors being placed at the base of the projectors. The controllers and the usual steadying resistance are shown with the projectors. (*Mr. H. H. Johnson.*)

Messrs. Crompton and Co. have been closely connected with the Government for many years on all matters relating to Projector design and construction, and in view of the large number of Projectors at present under construction it would be inadvisable at the moment to discuss many improvements which have been recently made in their design and operation. I can therefore only deal with this subject in a general manner.

It is very surprising to many people that up to the present there has been no serious effort to obtain a recognition by any of the official or technical societies of a reliable basis of comparison of the duties of electrical Searchlight Projectors.

The purchaser of a Projector sometimes specifies the illumination of a definite object at a given distance, or he may call for a Projector of certain candlepower or diameter. Now it is impossible for a manufacturer to guarantee a definite illumination at a given distance, as the test results depend largely upon local conditions, which are quite beyond the control of the manufacturer. For instance, a white buoy can be seen at a much greater distance than a black buoy, and further the size of the buoy (if that is the object to be illuminated) will have considerable influence on the result. Again, the question of what constitutes fair weather or clear atmosphere is very undecided, and cannot be defined in quantities which can be measured.

The illuminating distance of a Projector is not altogether a question of clearness of the atmosphere, but it is very largely controlled by the degree of humidity, as the distance at which one can see does not altogether depend upon the distance which the beam carries, but is governed by the screening of the effect of the haze of light which is formed round the beam, the amount of which depends upon the distribution of light which takes place in the beam. It is for this reason that an observer who stands some distance away from the beam of light can see to a much greater distance than if he stood near the beam, owing to his line of vision not striking the haze screen for some distance. From this it will be obvious that in weather which may be fairly clear to

the eye the projector beam may give very poor results if the atmosphere is very damp.

It has been found in practice that the absorption by the atmosphere may be as high as 50% if there is an excess of humidity.

From some recent tests which were carried out, it was found that a 20-inch Projector burning 60 amperes at 50 volts across the horizontal arc, and fitted with a parabolic silvered glass mirror having a 12-inch focus, would carry a distance of two miles and satisfactorily illuminate a white buoy approximately 3 feet by 3 feet.

From another test on a 36-inch Projector burning 150 amperes, and fitted with a parabolic glass mirror with a 17-inch focus, a white screen 6 feet by 6 feet was satisfactorily illuminated at five miles.

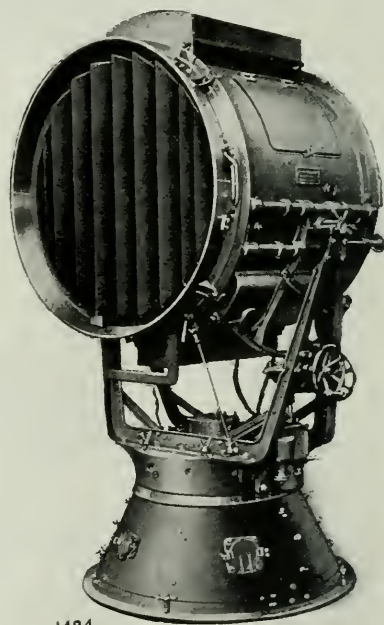


FIG. 3.—Standard 36-in. diameter hand-controlled projector, fitted with a "Louvre" flashing shutter operated by a lever from the back of the projector for signalling purposes.

The question of specifying the power of a Projector in candlepower is very misleading and really meaningless, although certain manufacturers still use the term. If any power of illumination



FIG. 4.—Portable 36-in. diameter electrically operated projector and cable drum for field purposes, as supplied to a foreign power. (*Mr. H. H. Johnson.*)

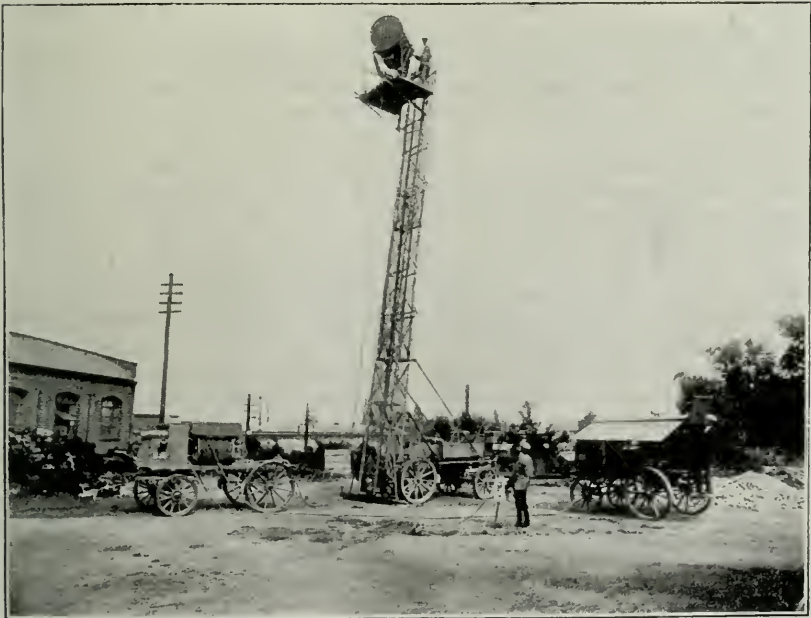


FIG. 5.—Field service military equipment, comprising petrol-driven generator, projector, distributing cable, and tar waggon, all arranged for distant control, as supplied to a foreign power. (*Mr. H. H. Johnson.*)

is to be stated, it should be in lux or other similar unit, but most manufacturers prefer to sell Projectors by stating the diameter and the normal current of the lamp. The diameter should, of course, refer to the mirror and not to the Projector barrel. This appears to be quite satisfactory provided that an efficient mirror is employed (which is usually of the silvered glass parabolic type) and that the carbons are free from impurities.

With regard to metal mirrors, I should like to obtain more information as to the efficiency and their possible commercial use in sizes from 16 inch diameter and upwards. This type of mirror is used in the smaller and cheaper class of Projector, usually of American or Continental manufacture, but presumably the metal mirrors are not often constructed in the larger sizes owing to distortion due to the high temperature and their inefficiency. The advantage of the metallic mirror as regards freedom from breakage has been largely discounted by using glass mirrors fitted with Parsons' Patent system of wired backs and improvements in their suspension and ventilation.

One of the modern improvements in commercial Projectors has been in connection with the Parsons' Split Mirror, which consists of a glass parabolic mirror divided vertically, and hinged in order to give either a parallel beam or a 15 degrees diverging beam with a 5 degrees dark centre so as to conform to the Suez Canal requirements.

Projectors placed on the foremast of the ship or on the chart house can be efficiently operated from a distance either electrically or mechanically.

Projectors for naval and military purposes will no doubt in future have to be capable of control from a distance and of operating with a vertical beam for anti-aircraft purposes.

The accompanying series of illustrations, showing some modern types of apparatus, will no doubt be of interest.

MR. A. KITSON (*communicated*):—

Mr. Ledger has given us a very interesting account of the developments of electrical apparatus used for searchlights, and, considering the comparatively short

time these have been in use, progress has been very remarkable. His paper, however, deals only with searchlights applicable for disclosing objects at a very great distance.

There is another field in which these high, less intensive lights, such as the acetylene and incandescent oil light, are extremely useful. It must be borne in mind that a very intense beam has necessarily a dazzling effect on the eyes of people on the vessel illuminated. While recently crossing from Holland I was particularly struck by the dazzling effect of the searchlights from Dover Harbour, and there are many cases in which excess of glare would be a drawback.

A searchlight which is serviceable at a distance of three or four miles, therefore, is not necessarily the best light for searching distances of, say, 500 to 1,000 yards. Recently I have been experimenting with searchlights for river purposes, and I find that incandescent oil lighting is admirably suited for such work, since the glare is less and objects can be distinguished at a moderate distance far more readily than with sources of very high candle-power and intrinsic brilliancy.

With regard to the atmosphere, this is a subject which has not been sufficiently investigated. The penetrating power of searchlights is, as stated by Mr. Ledger, greatly obstructed by fogs and mists, and in this case the colour of the light seems to play a somewhat important part. Some fourteen or fifteen years ago, when the system of lighting with which my name is associated was first taken up by the Trinity House Authorities for the lighthouses, a series of experiments were made at the High Lighthouse at Lowestoft (which was the first British Lighthouse to be equipped with this system), and it was found that during a very heavy mist the light was sufficiently strong to throw distinct shadows on Gorleston Pier, a distance of, I believe, eight miles. I understand that the lamps previously used were incapable of throwing the light so far in misty weather. This peculiar quality of the incandescent oil light has made it very serviceable in lighthouse illumination. About the same time, an experiment

was made in the lighting of one of the London streets, viz., Portland Place, and it was also noticed by the residents and the police authorities that during some of the very severe fogs prevalent at that season objects were far more distinguishable under the incandescent oil light than in any other part of London. The late Lord Roberts, who at this time was a resident of Portland Place, remarked himself this particular quality of the light. He stated to one of my employees that during the densest fog he was able (without difficulty) to read his papers in his front rooms facing the street, from the oil lamps which were erected in the centre of the thoroughfare.

It has been claimed that this is due to the presence of the red and yellow rays. There is a great field here for further investigation. For many years I have believed that we should ultimately be able to produce a light which would penetrate fogs for a very considerable distance, and render navigation and traffic as safe as in clear weather.

A further illustration as to the utility

of the incandescent oil light in fogs was shown in the testimony given by some of the officials of the steamship "Suevic," which was wrecked some years ago near the Lizard. The Lizard Lighthouse was at that time equipped with the electric light system, and the "Kitson" Oil Light was used as an emergency light. One of the officers of the wrecked steamer stated that it was his belief that if the oil light had been burning on the particular night in question his vessel would not have met with the accident which led to her becoming a wreck. Whilst the electric light was imperceptible, he was able to see what afterwards was discovered to be an oil light burning in a cottage near the coast. The development of the searchlight will, in my judgment, play a very important part in our coast defences in the future, and there is no country in the world which would benefit more by the discovery of a light which would enable our vessels to be seen clearly for a distance of at least 2,000 yards in the heavy fogs with which this country is afflicted.

SEARCHLIGHTS USING HALF-WATT LAMPS.

In a recent number of the *Electrical World** there is a reference to the applications of half-watt lamps for searchlights. With lamps of this type having a short stable filament and yielding 1000—2000 candle-power, a powerful beam can be obtained, and the power required is so small that the whole equipment can be mounted on an automobile of moderate size or, in case of need, carried for a considerable distance by men or horses. The article continues:—

"A beam of light intense enough to detect the movement of hostile forces at 2,000 yds. should

be of great value, particularly when the apparatus is light enough to be readily shifted about in the trenches so that it may reappear in a different spot long before hostile artillery is able to get its range. Night attacks seem to be especially frequent, and sufficient light to disclose them even at a distance of a few hundred yards gives a chance for action in a period long enough to insure a repulse. Such search-lamps ought to be particularly valuable in repelling airship attacks, since their range is certainly adequate, except in very thick weather, when airships themselves are likely to go astray, to pick up an object the size of a Zeppelin at any height attainable by such craft. With an incandescent search-lamp mounted on a fast automobile and followed by another with machine guns it ought to be possible to keep an airship once detected under fire for a long period. For such military uses the incandescent search-lamp seems peculiarly fitted, and it will be rather surprising if it does not come into considerable use."

* *Electrical World*, December 26th, 1914.

SOME NOTES ON THE CONDITIONS DETERMINING THE CANDLE-POWER AND STEADINESS OF LARGE CURRENT ARCS FOR SEARCHLIGHTS.

By MRS. HERTHA AYRTON.

I BELIEVE I can most usefully contribute to this discussion by giving the results of my own experience in the course of three investigations. These were undertaken for the purpose of finding out under what conditions such large-current arcs as are used for searchlights will emit the maximum of light for a given current while remaining always perfectly steady. The first two were made for a public authority, the third, of the same type though for a different purpose, for a cinematograph company.

The first series of experiments, made in 1905-6, was somewhat in the nature of a trial trip. For the second, carried out in 1906-7, the specified current was 120 amperes, and the lamp to be used, a horizontal-carbon automatic-feed Crompton lamp in a 36-in. projector, was supplied by the Authority. I was required to find the best carbons to use in such a lamp and to state what voltages at the terminals of the generator and the lamp should be employed in order to obtain a perfectly steady arc giving the largest possible amount of light with the carbons I specified. The third series was carried out in 1913, and in this the only thing specified was the current of 85 amperes; in everything else I had a free hand. The general conclusions arrived at as a result of all three investigations are given below.

CONSTANT VOLTAGE AT TERMINALS OF GENERATOR.—It cannot be too strongly insisted on that you cannot hope to maintain a steady arc unless the P.D. at the terminals of the machine is very considerably higher than that required at the terminals of the lamp. Only within the last year I have seen attempts made by a responsible body to maintain an arc requiring quite 60 volts with a dynamo that could only give 65 volts. The

pitiable results of alternate hissing and extinction were quite bewildering to the operators who had been set the impossible task. If such a low voltage dynamo were the only one obtainable, then the carbons and current used should have been altered to suit this condition; but authorities have not yet learnt the lesson that the arc is a rebel and cannot be coerced. A very good rule is for the generator to be capable of giving a constant voltage from 30 per cent. to 33 per cent. higher than that required at the terminals of the lamp. In my second investigation, for instance, in which 120 amperes was specified, I found that I got the maximum of light with an arc taking 70 volts at the terminals of the lamp, and that to have this perfectly steady needed a constant 95 volts at the terminals of the machine. This was using a solid positive carbon. When a cored positive was used, the light given out was less, but the lamp voltage was then 60, and the dynamo voltage 80; the proportion, therefore, was much the same.

LAMPS.—The Crompton horizontal-carbon automatic-feed lamp worked remarkably well but for two easily-remedied defects—the one connected with the iron horse-shoe mentioned by Mr. Ledger and the other with the automatic-feed mechanism. With horizontal carbons, when they are placed with their axes in line, the upper part of the positive burns much faster than the lower, owing to the rising of the flame. The crater than burns in a slant and a “lip” forms below, giving rise to unsteadiness. The object of the horse-shoe, which becomes magnetised by the burning arc, is to send the flame down and keep it well between the carbons, so that the crater shall burn vertically. I found, however, that it was

impossible to maintain a really steady arc with the horse-shoe in position, and so I discarded it, and tried placing the negative carbon so low that the lower part of the positive burnt as fast as the upper. This was quite successful. Without the magnet, when the lower surface of the negative is placed about on a level with the lower surface of the positive, the crater burns in a perfectly vertical plane and the arc is quite steady. The question of the exact level is a matter of trial with each pair of carbons, but it soon becomes evident whether the crater is burning away more above than below or *vice versa*, and one of the carbons is then raised or lowered to set matters right.

The second defect in the Crompton lamp had to do with the feeding mechanism. This fed the carbons when the voltage at the terminals of the lamp reached any given P.D. for which it was adjusted. As the coils of the mechanism warmed up, however, the feeding took place at a higher and higher voltage, so that the arc got longer and longer each time before the carbons were fed. The remedy was to watch the voltmeter and readjust the feeding mechanism from time to time. The difficulty would be hardly worth mentioning but that operators are apt to forget that the amount of light given out and the steadiness of the arc both depend upon this voltage.

Horizontal carbons are not the best for searchlights, however; the negative obscures too much of the light of the crater; inclined carbon lamps also are unsuitable, I consider, both for them and for cinematograph work. There are several angle lamps on the market, but as I could find none that was satisfactory I had one made early in 1913 so that I could alter the angle between the carbons within a wide range, and all my subsequent experiments were made with that lamp. I finally came to the conclusion that the best results were obtained with the positive carbon horizontal and the negative making an angle of about 150° with it. The inventor of the ingenious lamp described by Mr. Eck seems to have gone through the same process with much the same result.

It is usual to attach mechanisms to the lamp which enable the positive carbon

to be moved relatively to the negative vertically and horizontally. In mine I had the horizontal motion given to the negative carbon, and I believe that both motions ought really to be given to that carbon, for the reason that, as the crater is the source of light, when it is once focussed it should never be moved relatively to the lens and mirror except for the inevitable feeding.

A good lubricant for all the various mechanisms of the lamp is a most important item in its smooth working. None containing oil ought ever to be used (yet the only ones on the market all contain oil, I believe) because the oil quickly becomes solidified with the heat and clogs the racks causing them to jam. The perfect lubricant is a thin mixture of turpentine and powdered black lead of the kind used to polish the domestic grate. A thin coating of this, painted with a stiff brush on to all the working parts, will keep the lamp working smoothly many hours a day for a month at a time. It was revealed to me by a clever cinematograph operator.

CARBONS.—*The Positive Carbon.* For Searchlights a solid positive carbon is to be preferred whenever it is possible to use a generator giving high enough voltage. With a good solid positive carbon the crater never cracks and breaks, there is no core to drop out, and the intrinsic brilliancy of the crater is higher. The carbon has to be larger than a cored carbon for the same current, but it burns more slowly, even in proportion to its diameter, and therefore is in every way more economical. The only disadvantage is that the light is a little more apt to move about over the crater than with a cored positive carbon, but without any hissing or sputtering or real unsteadiness following.

Negative Carbons. The choice of the negative carbon has, perhaps, more effect on the steadiness of the arc than any other single factor that can be named. The well-known desiderata are that its tip shall present only a small surface for the arc to rest upon, and, for searchlights, that the carbon shall burn away at exactly the same rate, length for length, as the positive. The search for the perfect negative carbon was by far the most

difficult part in all my three investigations. A slender solid negative burnt well but much too fast; a thick one burnt more slowly, but with such a blunt rounded tip that the arc was never steady when it had once formed. In 1905-6 I reduced the surface of the tip in two ways: I used as negative a cored carbon which had been made for a positive, so that, as the core always burnt faster than the outside shell, leaving a shallow hollow in the middle, there was only a ring of carbon at the tip for the arc to rest on. In order to make this ring even thinner, I reduced the diameter of the carbon and, to give it the necessary conductivity, to carry so large a current, I gave it a coating of copper, but a much thinner coating than had ever previously been employed. These were the first small diameter negatives for large currents ever made. The carbons I specified for the current of 120 amperes, for instance, were 38 mm. solid positive and 18 mm. cored, copper-skinned negative, the copper being 0.02 mm. thick; and the two burnt at exactly the same rate, length for length—about $1\frac{1}{2}$ in. an hour. The carbons previously used in the same lamp were 35 mm. cored positive and 26 mm. solid negative heavily coppered, so that the negative had a cross section rather more than twice as great as mine. With these carbons the arc was never steady for two minutes together.

In 1913 I devised two new kinds of negative carbons, both of which are applicable to searchlights. The first had a hard core, softer outer shell and copper skin; these are the type to which Mr. Ledger referred, only he mentioned a non-essential copper core and forgot the essential copper skin. The characteristic of these hard core carbons is that they burn always with a slender point of the hard core protruding; it is this that makes them burn so steadily. The distance to which the point protrudes and the length of the bare carbon tip both depend on the thickness of the copper skin, and this therefore determines both the steadiness of the arc and the rate of burning of the carbon; but a copper or coppered core is actually deleterious, for it has the effect of colouring the arc.

The second of the new types of negative is the best of all, because it is the simplest.

It is a hollow tube of rather soft carbon stopped up at the butt end to prevent the air whistling through, and with a copper skin. In this carbon also the thickness of the copper determines the length of the bare tip, and therefore the rate of burning. I find that one of these carbons 13 mm. in diameter with a hole 3 mm. in diameter and a coating of 0.03 mm. of copper burns with perfect steadiness at the same rate as the cored positive carbon 25 mm. in diameter. I used with it a current of 85 amperes.

The Shaping of the Carbons. In 1895 I published in *The Electrician* an article with numerous illustrations showing that the burning ends of the carbons acquired a distinctive shape which I called the "normal" shape for each current and length of arc with which they were burnt. This fact, which was discovered by Prof. Ayrton and his students, and to which I devoted the whole first chapter of my book, "*The Electric Arc*," has become so much a matter of common knowledge that I was a little surprised to hear that Captain Ohnstad had re-discovered it in 1914. When it is remembered that if a constant current and length of arc are maintained the voltage, as we showed,* changes continually till the carbons have acquired their normal forms, the importance of their being manufactured to those forms to start with will be realised. I found, for instance, with the Crompton lamp, that the carbons could start being automatically fed in from two to four minutes after the arc was struck, if the carbons were normally shaped, but that they had to be hand fed for fully 40 minutes before the mechanism could be started if they were shaped as they usually come from the manufacturers, because during all that time although the distance between the carbons and the current were kept constant, the voltage changed continuously.

Waste of Carbons. While on the subject of carbons I must mention the waste entailed by the present plan of throwing away the used ends while they are still several inches long. This is not only wasteful in itself, but in field searchlights, for instance, and in possible aeroplane searchlights, where the saving of weight

* *The Electric Arc*, p. 112 et seq.

is a great consideration, it is highly important that the practise should be altered. I have devised a very simple supplementary holder in which all such ends can be placed, and burnt so that, at most, an inch and a half remains.

LAMP ENCLOSURE.—It is very necessary that the lamp enclosure should be symmetrically ventilated as regards the two sides, and that there should be no back opening. I found I could not get a steady arc in the Crompton lamp till I had placed a sheet of asbestos in the opening at the back of the barrel. The side ventilation was perfect, but this opening gave rise to great trouble. For cinematograph work I have devised a lamphouse with double walls, the inner of wire gauze and the outer of asbestos separated by distance pieces made so that there is a constant flow of cold air between the two sets of walls, which carries most of the heat from the arc well up away from the operator. It is so light that it would, I think, be applicable, with a lens only and no mirror, for searchlights watching for aeroplanes, and for field and aeroplane searchlights.

AMMETER, VOLTMETER AND VARIABLE RESISTANCE.—All the precautions taken to ensure the possibility of a good steady arc will be useless unless the operator is allowed to have what may be called the right tools for his part of the business. Both a good ammeter and a good voltmeter are indispensable, and even they are of no avail unless they are placed where he can easily read them at the

same time that he is attending to the arc—if, for instance, they are behind him or hidden in any way from him, they may as well not be there, and yet neither of these cases is unheard of. He must also have a variable resistance well within reach, not only to put in when he starts the arc, but also for bringing the current back to its right value when any accidental disturbance takes place. It ought to be unnecessary to mention these precautions, but it is not.

Again, it is well known that if the carbons get out of line, so that the crater burns on one side, a hissing unsteady arc is almost inevitable; yet the operator is not usually allowed to touch the handles that bring them into line, or, if he is, they are inside the lamp enclosure, and he has to burn his hands by manipulating screws that are quite close to the arc. It is absurd to expect him to keep the arc steady under such circumstances. *All* the handles that move every part of the mechanism of the lamp should, on the contrary be cool and easily got at, and he should be trained to use them with discretion.

Finally, I am afraid I must disagree with my friend Mr. Trotter as to the kind of arc to be aimed at. A humming arc is too near a hissing arc; in fact, it is in the first stage of hissing. The perfect arc is a silent arc, and if you cannot get it, you must get it as silent as you can.

I must apologise for mentioning so many of my own devices, but as they were evolved just because I found they were needed, it has been impossible to help referring to them.

THE ARC UNDER HIGH AIR PRESSURE.

The *Electrical World* for January 30th contains a summary of some interesting researches on the arc by Prof. O. Lummer, of Breslau. It appears that the temperature of volatilisation of carbon, and therefore the intrinsic brilliancy of the arc crater, is a function of the pressure of the surrounding air. Ordinary fluctuations in barometric pressure do not affect it greatly, but with a pressure of 22 atmospheres Lummer found that the surface

brilliancy was as much as 23 times the value under ordinary conditions. At this enormous pressure he estimates the temperature of the crater to be as much as 6,000 degrees absolute, which is not far removed from the reputed temperature of incandescence of the sun.

In these researches Prof. Lummer used special impregnated carbons. The result is certainly an interesting one from a scientific standpoint, as well as having possible important practical applications for searchlights, and deserves to be investigated in this country.

PRACTICAL AND THEORETICAL NOTES ON PROJECTORS.

BY A. P. TROTTER.

THE actual working and use of a searchlight can be learned in a few practical lessons. Knowledge of the theory will be of little help. Acquaintance with the thermodynamics of internal combustion engines or of the design of gear teeth does not help anyone to drive a car.

Practical Hints.

My own experience has been chiefly with the Crompton automatic lamp. When this is in good order there is nothing to be said about it: it looks after the arc, hour after hour, keeping it in perfect adjustment without any attention. If it has been misused, more directions are needed than can be given in this article, and to understand the matter needs some little acquaintance with electrical matters. A large number of hand-fed lamps are in use, and a few elementary hints may be given on running them, based on my experience 15 years ago.

For the purpose of keeping a steady arc it is necessary to have a resistance in series with it. This has an incidental advantage that the carbons may be short-circuited without burning anything up. The carbons should be thoroughly dry and firmly fixed in line. Close them together and snap the switch to see if there is a short circuit. If there is not, the cables and resistance will carry the big current; if there is, the fuse will blow, and the short must be looked for. If not, close the switch and open the carbon, slowly. Until they are well hot they will not hold a long arc, and the arc will go out if lengthened too quickly. A short arc will hiss, a rather longer arc will hum, and a longer one will run silently. If too long the crater (the bright face of the larger carbon) will become uneven and the arc will wander about, burn irregularly, spoil the shape of the carbons, and go out. The shortest possible silent arc or low humming arc is best. If the positive (the

face, bring the carbons together to give a roaring or hissing arc, but do not let them touch. If hissing is allowed to persist, a mushroom will grow on the negative and interfere seriously with the light. It will burn off if the carbons are separated. It is better to break the arc by separating the carbons than to use the switch. When the carbons burn away to about 3 inches they must be changed. To do this quickly without burning one's fingers is a matter of practice.

In quiet surroundings the best guide to the best length of arc is a low hum. In hand feeding, the handle may be turned until the arc just hisses, and then turned back a little. Experience will show how often feed is needed. Another way is to watch the ammeter and voltmeter.

The searchlights in London are being run on 200 volts. There is therefore a large resistance in series, and this makes it easier to keep a steady long arc. Hissing under these conditions may occur with an uneven or skew arc of considerable length. Practice alone enables a steady one to be maintained.

Theoretical considerations.

In its proper place, and with the necessary qualifications and limitations which mathematicians are sometimes apt to overlook, the theory is interesting, and of course, for the design of projectors, is essential. I was asked recently whether one of the searchlights which are being used in London could burn a hole in a haystack at half a mile. This question was evidently inspired by a slender acquaintance with theory. It is conceivable that a mirror could be made with sufficient accuracy, but the heat would have to be concentrated on a patch of not more than 2 inches or 50 mm. diameter at 805 metres. With a 90/42 projector, that is, with a mirror 90 cm. diameter and 42 cm. focus, the diameter of the crater of the arc would have to be only

$(50 \times 420) / 805000 = 0.026$ mm. or one thousandth of an inch, and it would be impossible to use a current of 120 amperes.

Theory tells us that the light emitted from a focal point of a paraboloidal mirror is reflected as a parallel beam. But in practice we are not dealing with focal points, but with arc craters as large as a shilling, say 22 mm. in diameter. The middle part of a 90-cm. or 36-inch mirror of 42 cm. or $16\frac{1}{2}$ in. focus has at the centre a radius of curvature of 820 mm. or 33 in. The outer parts have a flatter curve. The depth is about 115 mm. $4\frac{1}{2}$ in. Fig. 1 shows such a mirror. The

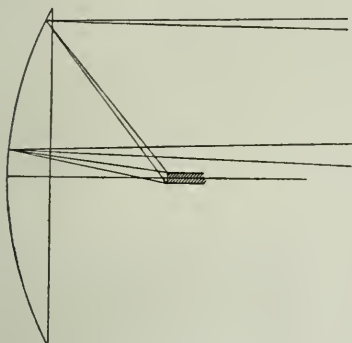


FIG. 1.

crater, 22 mm. in diameter, subtends an angle of about 3 deg. to a point at the middle of the mirror, and about $1\frac{1}{4}$ deg. to a point at the edge. In practice the divergence may be taken as an average of 3 deg. At half a mile the beam is about 139 feet in diameter. If an attempt is made to concentrate the rays by moving the lamp away from the mirror, the outer rays which have less convergence will cross, and the beam will be irregular. The best place for the crater is the focus, and the natural divergence is generally the best. It is possible that for showing up a flotilla of aircraft a divergent beam produced by racking the lamp in, might be useful.

The theory of projectors has been discussed by F. Nerz, Prof. Blondel, and Capt. Bremner. Prof. Blondel says that "the useful effect of a projector may be defined (1) by the luminous intensity (or, as we say, candle-power) at a great distance, measured in the axis of the beam, which determines the limit of range

with which the projector can, according to the state of the atmosphere, produce a sufficient illumination; and (2) the angle and homogeneity of the beam which determines the area usefully illuminated." In practice, the range is a rather indefinite quantity. It is the distance at which objects can be recognised by means of the beam. So much depends on the colour and size of the object and of its background, and on the atmospheric conditions, that the range of a searchlight must be left to the practical judgment of an experienced man, and can hardly form a matter for calculation.

The candle-power of searchlights and lighthouses is often described in large figures, but they mean little. A parallel beam has no measurable candle-power. Such a beam produces the same illumination on a surface perpendicular to the axis, at whatever distance it is placed. With a convergent beam the expression candle-power is meaningless. If the rays from a projector all had a uniform divergence of 3 deg. they might be considered to be emitted from a point source behind the mirror at a distance of 19 times its diameter.

The mirror acts, along the axis of the beam and through a small angle with that axis, as a source of light. Under laboratory conditions the coefficient of reflexion might approach 85 per cent.—in practice it is likely to be nearer 75, and the transmission through the window will bring the light down to about 65 per cent. A mirror, says Prof. Blondel, behaves at a great distance exactly as a plane incandescent surface having an intrinsic brilliance the same as that of the source of light, multiplied by the coefficients of transmission and reflexion. In 1894 I found that the crater of an arc gives under best laboratory conditions 170 candles per sq. mm. Prof. Blondel found a similar value. In practice it will not average more than 120 over the whole crater. Each square millimetre of the mirror may be assumed to have a brilliance of 120 candles, and a 90 cm. mirror gives therefore about 50,000,000 candle-power.

A paradox lurks here. A paradox is generally the result of unsound reasoning. This calculation is based on candles per square millimetre of the crater, and not

on the total candle-power. It would therefore hold good if the positive carbon were the size of the lead of a pencil with an area of one square millimetre and a candle-power of 120. With a 90 cm. projector a positive carbon of 32 mm. diameter is generally used, giving a crater rather less than the full diameter, 20 mm. dia. and 314 sq. mm. area, and a candle-power of 38,000. If this reasoning is sound, the candle-power of the beam is independent of the candle-power of the lamp. The mistake is in the use of candle-power to describe the useful effect of a projector. If when viewed from a distance each square millimetre appears full of light, nothing can make it more full except an increase in the intrinsic brilliancy of the crater.

Increasing the area of the crater increases the divergence. The candle-power remains the same, and the flux of light is increased. The polar curve for a pro-

jector with a small crater, giving a divergence of 2 deg. and for the same projector with a crater of twice the diameter of the first, but giving the same candle-power in each case, is shown in Fig. 2.

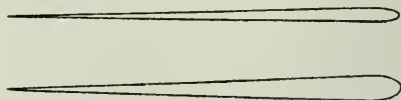


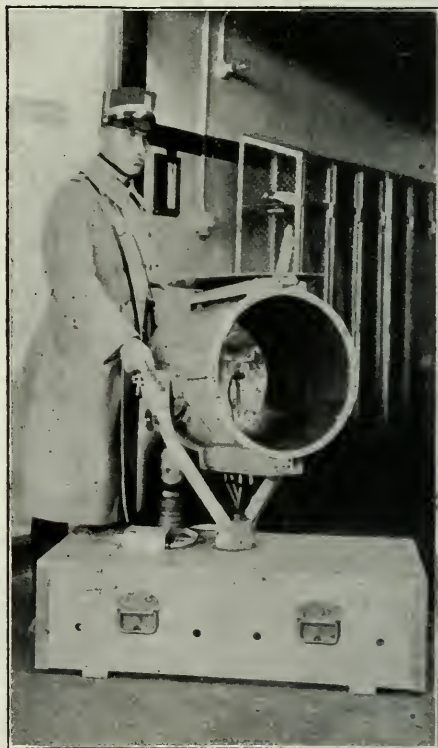
FIG. 2.

The flux of light from the crater and the flux of the beam may both be calculated, but it is hardly worth while, on account of the uncertainty of the amount of light obstructed by the negative, and the period which may have elapsed since the mirror was polished. A candle-power of 50 million will give an illumination of about 7 foot-candles at half a mile, and this on a disc of 140 ft. diameter is equivalent to about 100,000 lumens.

THE OXY-ACETYLENE SEARCHLIGHT.

A CORRESPONDENT sends us some particulars of the oxy-acetylene searchlight which is being widely adopted in the Swedish Army.

This apparatus employs a pellet of ceria on which the oxy-acetylene flame is concentrated. The standard form of searchlight is equipped with cylinders containing about 1,000 litres of dissolved acetylene and about 1,100 litres of compressed oxygen. While in use about 40 litres of acetylene and 40 litres of oxygen are consumed per hour, so that the searchlight could be used for about 20 hours without replenishing. The searchlight is stated to give about 1,500,000 candles.



An Oxy-acetylene Searchlight as used in the Swedish Army.

A METHOD FOR DETERMINING THE RANGE OF SEARCHLIGHTS.

BY PROF. A. BLONDEL.

THE "range" of a projector is the distance at which one can distinguish an object illuminated by it. The range depends on the transparency of the atmosphere; the dimensions of the object illuminated; the colour, form and nature of the surface of this object; the degree of contrast with surroundings, &c. The problem of determining the range as a function of these various quantities is much more complex than is generally believed. It is necessary to take account not only of the physical and geometrical properties of the beam of light, but also of the influence of telescope, glasses, or spectacles and of the physiological idiosyncrasies of the observer's eyesight.

I propose to discuss the problem successively (a) from the purely physical standpoint (illumination produced) and (b) from the physiological standpoint (visual acuity).

NOMENCLATURE.

Let us denote by—

I , the *luminous intensity* of a source equivalent to the searchlight beam, in mega-candles.

x, x_1 , respectively the *distances* from the mark or object illuminated to the projector and the observer, in kilometres.

$l = x - x_1$, the *difference between these distances*.

E , the *illumination* received in the neighbourhood of the object, (*i.e.*, the luminous flux received by a plane surface, divided by its area).

a , the *coefficient of transmission* of the atmosphere (the fraction of the incident light that traverses a thickness of 1 kilometre of air).

g , the *magnification* of the glasses used by the observer.

k , the *coefficient of transmission* of the optical system of these glasses.

$R = \log \left(\frac{k \cdot d^2}{p^2} \right)$, a function for the glasses.

d , diameter of the ocular image of the objective lens of the glasses.

p , diameter of the pupil-aperture in the eye.

E_0 , minimum illumination in lux required to enable the illuminated object to be distinguished by a person having normal acuteness of vision.

$H = \log E_0$, another empirical constant.

V , *acuteness of vision* factor.

b , a coefficient depending on the dimensions of the illuminated object.

B , an empirical coefficient, specifying the effect of *form, colour* and *contrast* of object, in regard to surroundings.

$L = Bb$, an empirical constant defining the distance at which vision objects can be perceived by a person of normal acuity under an illumination ten times as great as E_0 .

ILLUMINATION OF OBJECT.

The illumination would be $\frac{I}{x^2}$ except for the atmospheric absorption. The actual illumination will be reduced to

$$E = \frac{I}{x^2} a^x,$$

a being the coefficient of transmission, as mentioned above, and less than unity. Transposing into logarithms we have the equation:

$$\log E = \log I + x \log a - 2 \log x.$$

But this statement of the illumination of the object is not sufficient to determine its *visibility*, which depends on the apparent brightness¹ of the object. The

¹ Several observers have been led into the error of supposing that the apparent brightness of an object can be expressed by some such formula as:—

$$\frac{I \cdot a}{(x + x_1)^2} \quad \text{or} \quad \frac{I a^{x+x_1}}{x^2 x_1^2}$$

In the first case it is assumed that the brightness varies according to the inverse square law. These formulæ are entirely incorrect, for they do not take account of the fact that the acuteness of vision falls off as the distance increases.

visibility is therefore affected by the reflecting power of the object illuminated and on any factors operating between the eye and the object and tend to reduce its brightness, such as the interposition of a greater or less thickness of air, and also, as a rule, spectacles or glasses used by the observer.

In practice the minimum illumination necessary to enable an object to be seen depends on its colour and form and the texture of its surface. The intensity *I* is known. It may be measured direct photometrically,¹ or it may be calculated approximately in the case of an

and also by a factor allowing for the absorption of the mirror and the glass window.²

The transmission coefficient is generally less than the value 0.973 given by Bouguer for a very clear atmosphere. On land it depends chiefly on the amount of dust and water vapour in the atmosphere in the quarter through which the projector's rays are received, and can only be determined by very methodical observations. At sea this coefficient is much better known as a result of investigations in the lighthouse service, which has prepared tables indicating the

TABLE I.—VARIATION IN TRANSMISSION COEFFICIENT DURING THE YEAR IN FOUR CHIEF COAST REGIONS OF FRANCE (AFTER ALLARD).

Corresponding to Mean Transmission Coefficients.								
Proportion of the year <i>n</i> .	Channel Coast.		Brittany and Cotentin midway between the Channel and the Atlantic.		South-west Coast (Atlantic Ocean).		Mediterranean.	
	<i>p</i> .	<i>a</i> .	<i>p</i> .	<i>a</i> .	<i>p</i> .	<i>a</i> .	<i>p</i> .	<i>a</i> .
0	10.00	1.000	10.00	1.000	10.00	1.000	10.00	1.000
$\frac{1}{10}$ or 0.083 ..	8.48	0.962	8.48	0.962	8.48	0.962	8.55	0.964
$\frac{2}{10}$ or 0.167 ..	8.06	0.948	8.06	0.948	8.09	0.949	8.13	0.950
$\frac{3}{10}$ or 0.250 ..	7.75	0.936	7.79	0.938	7.84	0.940	7.88	0.941
$\frac{4}{10}$ or 0.333 ..	7.48	0.925	7.58	0.929	7.69	0.934	7.78	0.937
$\frac{5}{10}$ or 0.417 ..	7.22	0.914	7.38	0.921	7.51	0.926	7.71	0.935
$\frac{6}{10}$ or 0.500 ..	6.93	0.900	7.15	0.910	7.31	0.918	7.65	0.932
$\frac{7}{10}$ or 0.583 ..	6.58	0.880	6.88	0.897	7.07	0.906	7.60	0.930
$\frac{8}{10}$ or 0.667 ..	6.24	0.860	6.50	0.876	6.80	0.893	7.54	0.928
$\frac{9}{10}$ or 0.750 ..	5.77	0.826	5.98	0.842	6.40	0.870	7.40	0.922
$\frac{11}{10}$ or 0.823 ..	5.12	0.770	5.35	0.791	5.77	0.826	7.12	0.909
$\frac{12}{10}$ or 0.917 ..	4.08	0.644	4.33	0.678	4.67	0.722	6.55	0.979
$\frac{13}{10}$ or 1.000 ..	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000

p is the limiting distance, measured in kilometres, at which one can still see distinctly a luminous source with an intensity equal to $\frac{1}{10}$ candle. A knowledge of *p* thus gives a measure of the coefficient of transmission *a*.

electric arc light by multiplying the projected area of the crater facing the mirror by the intrinsic brilliancy of the arc (which usually varies between 150 and 200 candles per square millimetre, according to the current density)

conditions existing on various portions of the sea coast (the Channel, Ocean, Mediterranean, etc.).

Table I., for example, indicates the proportion of the year (denoted by "*n*") during which the coefficient of transmission is greater than the value mentioned above.

¹ Such measurements are rendered particularly simple by the use of a portable "lux-meter," which enables the illumination to be determined with precision down to $\frac{1}{10}$ lux.

² See A. Blondel, *Théorie des Projecteurs Electriques de Lumière* (Octavo, 1894, 2nd edition).

Now let β be the coefficient of diffuse reflection of the surface.

The illumination received by the surface is

$$E = \frac{Ia^x}{x^2}$$

The apparent brightness of the object, as seen by the observer, is

$$i = \frac{\beta \cdot E}{\pi} = \frac{\beta \cdot Ia^x}{\pi x^2}$$

which is independent of the distance if the transmission coefficient $a=1$ (since the quantity of light received by the eye raises inversely as the square of the distance, but so also does the area of the retinal image). Allowance must in practice be made for the effect of absorption in the atmosphere. Assuming that the diffusion follows Lambert's law, so that the brightness is independent of the angle from which it is observed, one can finally write for the value of the apparent brightness of the screen, the expression:—

$$i = \frac{\beta \cdot Ia^{x+r_1}}{\pi x^2}$$

Denoting by E' = the "apparent illumination" of the screen, we can put the equation into a form more convenient for practice, thus:—

$$E' = \frac{Ia^{x+r_1}}{x^2} = \frac{Ia^{2x}a^{-l}}{x^2} = \frac{1}{a^l} \cdot \frac{Ia^{2x}}{x^2}$$

whence $\log E' = \log I + 2x \log a - 2 \log x = l \log a$(2) l being the difference in the distances of the projector and observer from the object illuminated.

As will appear later the above equation is easily expressed in graphical form.

For each variety of object there will be a certain minimum illumination needed.

If one knows the minimum illumination which must be available in order to distinguish clearly objects having a reflecting power β , the above equation will determine the range; conversely it enables us to calculate the candle-power, I , necessary to realise a minimum illumination E_{min} at a distance, x , if one knows the difference in distances, l .

In this connection it is interesting to note the following values for the reflection

coefficients of surfaces, similar to those encountered in practice:—

	Coeff. of Reflection.
White blotting paper	0.7—0.8
Fresh snow	0.78
White cardboard	0.6—0.7
Whitewashed wall, clean	0.5
Plank " of deal wood, clean	0.2—0.25
Plank " " " " dirty	0.4
White sandstone	0.2
Clay	0.24
Muddy and trodden earth	0.16
	0.08

There is no necessity to make use of a great number of different values for a , for this quantity is not known with any great precision, and when it has fallen to a low value the atmosphere loses all transparency; one might, for example, work with values of 0.5, 0.6, and, under the best conditions, with 0.7, 0.8, 0.9 and 0.97.

EFFECT OF GLASSES.

When an observer is very distant he will probably make use of glasses,¹ resulting in a certain magnification of objects which is favourable to visual acuity, but on the other hand entails a corresponding diminution in apparent brightness.

In the case of a Galilean telescope the diminution in brightness is diminished by the transmission coefficient, k , of the lens system, including the absorption by the lenses and the loss in reflection from the various surfaces traversed. In the case of the prismatic glasses used in the modern field glasses the coefficient of absorption, k , is much greater and must be multiplied by the quantity

$\frac{d^2}{p^2}$, d being the diameter of optical aperture of the system, and p , that of the pupil (p = approx. 8 mm. by night).

The factor of reduction is then $k \frac{d^2}{p^2}$

The coefficient $k \frac{d^2}{p^2}$ may be determined experimentally with sufficient exactitude by observation of the brightness of a white screen illuminated with approximate uniformity by means of

¹ The acuteness of vision attained with field glasses is very much greater than that obtained by the aid of spectacles.

a lamp placed behind the observer. The eye of the observer should be furnished with an artificial pupil of 2.5 mm. aperture. One then asserts successively in between the eye and the screen the telescope (focused on infinity) and a weak glass of varied thickness, which can be adjusted until the diminution in brightness is the same as that caused by the telescope. By alternately introducing the telescope and the graded glass the point of balance is readily estimated and from a knowledge of its qualities the absorption of the telescope can be readily determined.

For night observations one should always choose a glass in which d is at least equal to p ; but this condition is rarely fulfilled and in general the diminution in brightness so occasioned goes far towards balancing the magnifications.

REALISATION OF THE DESIRED ACUTENESS OF VISION.

We have seen that the illumination, E , must enable the acuteness of vision¹ to suffice for the perception of detail. Whatever be the colour of the rays² of light from the projector (or, what amounts to the same thing, the colour

¹ In general, one measures acuteness of vision by the reciprocal of the limiting angle at which black type of a certain size can be seen against a white background. This angle is about 1 foot by 5 feet for a normal eye, with an illumination on mat white paper of 10–20 lux, which is equivalent to an area of 0.29 m. by 1.45 m. at a distance of 1 kilometre. If the objects to be distinguished subtend a smaller angle than the above, they cannot be distinguished. Conversely, if the angle is greater than this limiting value, a smaller illumination would suffice to make them visible, provided always, as Charpentier has shown, that a certain minimum illumination is available. The maximum acuteness under a high illumination may reach about 1.5–1.7.

² Nevertheless, acuteness of vision depends on the colour of objects, and the colour of the rays illuminating them. According to Langley the maximum sensibility is attained in the yellow-green and diminishes rapidly on either side of this point in the solar spectrum. But the spherical and chromatic aberration of the eye introduce complexities, and, in the case of distant objects the acuteness of vision is very low for blue rays. There is, therefore, no disadvantage in suppressing the blue rays in the spectrum of light from projectors.

of the object illuminated) acuteness of vision varies as a function of the illumination, or rather of the apparent brightness, of the illuminated object, which, again depends on its reflecting power. Moreover this function the same law if one designates E_0 , the minimum illumination necessary for distinct vision, as unity. This theory, first announced by Helmholtz,³ appears to have been confirmed by the researches of Koenig.⁴

According to Koenig's curves,⁵ whatever be the colour of the light the acuteness of vision, measured with respect to Snellen's types, varies as the logarithm of the illumination, following the double law of Fechner; that is to say, the relation connecting the above quantities would be two "jointed" straight lines having a different inclination, and corresponding respectively to vision by weak light ("rod vision") and vision by strong light ("cone vision"). The maximum acuity attained at weak illuminations is about 0.15. According to recent researches the point of transition from one state of vision to the other would appear to occur with a brightness in the neighbourhood of 0.05 to 0.1 candles per square metre, corresponding to an illumination on white paper of 0.25 to 0.50 lux⁶. This order of brightness is generally surpassed in the case of objects illuminated by searchlights (*a fortiori* when the country is covered with fresh snow).

Now, in actual practice, when Snellen's types are replaced by coloured objects perceived against a more or less relatively

³ Helmholtz, Handbuch der physiologischen Optik. I. Aufl. p. 443.

⁴ A. Koenig, Gesammelte Abhandlungen, p. 391, lines 6–20.

⁵ Koenig, Gesammelte Abhandlungen, p. 388.

⁶ See Percy W. Cobb (Trans. Illum. Eng. Soc. (U.S.A.), June, 1913, p. 293). According to Dow the change in the line occurs near 0.2 lux (Illum. Engin. Lond., April, 1909); Luckiesh (Trans. Illum. Engin. Society, U.S.A., April, 1912, p. 154) finds that the change is nearer 1 lux, with white paper. There is, therefore, a certain degree of inexactitude in obtaining these values absolutely and only experience can decide when the first portion of the diagram is applicable; the constants B and H will be varied according to the region on which we are working.

dark background, one should state Fechner's Law in the form :—

$$V = B \log \left(\frac{E}{E_0} \right) = B (\log E - H)$$

where B and H are two empirical constants, selected according to the character of the object observed, colour, background, &c., and the composition of the light illuminating them. B and H will vary according to the illumination, and the curve will consist of two broken rectilinear portions.¹

DETERMINATION OF CONSTANTS B AND H .

One can determine the above constants by making a series of measurements on a day when the absorption of the atmosphere is negligible, with a projector of known intensity, producing an illumination I/x^2 on the mark observed by the naked eye (so as to avoid complications introduced by the effect of glasses). We have then the following relation :—

$$\log E = \frac{V}{B} + H = \frac{x_1}{Bb} + H, \dots\dots(4)$$

where b specifies the dimensions of the object and b/x_1 is the angle subtended by it in radians, and $\frac{0.00029x_1}{b}$ is

the acuity in reciprocals of angles in minutes. One then makes use of a series of absorbing glasses, the values of which have been standardised beforehand, and having a known transmission coefficient, T . E can be altered at will

by interposing these glasses successively in the path of the searchlight. By this means we obtain the relation :—

$$\frac{x_1}{Bb} + H = \log I - 2 \log x + (x + x_1) \log a + \log T. \quad (5)$$

The constant, B , which one deduces from Koenig's work, will be about 0.43 with V expressed as a function of the normal acuteness of vision; this corresponds to a length of 1.45 metres visible at a distance of one kilometer. If the range is expressed in kilometres, the illumination E is measured in lux, and the characteristic dimensions of the object, b , in metres :—

$$B = \frac{0.43}{1.45} = \frac{1}{3}, \text{ whence } \frac{1}{Bb} = \frac{3}{b}$$

If, for example, an object gives an acuity, $V=0.2$ at 1 kilometre,

$$\frac{1}{Bb} = \frac{3.0 \cdot 20}{1.45} = 0.41.$$

If we vary x_1 (by altering the position of the observer) and also T in such a manner as to obtain always just the desired visibility, we can obtain a relation between x_1 and E . By plotting $\log T$ as abscissa and the first quantity in the equation as ordinate we obtain, if $\log a$ is negligible, a straight line whose

inclination gives the quantity $\frac{1}{L} = \frac{1}{Bb}$ and the intercept along the ordinate from the origin, the quantity H .

Better still, the observer could operate at different distances from the illuminated mark, inspecting the object through a double photometer with absorbing prisms, which is graduated direct in logarithms. The photometer will be regulated in such a way as to obtain at each distance the exact limit of visibility. One can thus, without varying I , construct the curve relating x_1 and $\log E$. I am at present constructing a small apparatus of this kind which could be conveniently employed on the direct vision principle; in this instrument an adaptation of the Galilean telescope may be used, and it is unnecessary to vary the candle-power of the source.

One could also operate in the laboratory with small models of ships, combatants and illuminated scenery. Thus, by using

¹ According to other experience, notably that of P. W. Cobb, any increase in brightness in the area surrounding the actual object under observation will considerably diminish the ease with which it can be seen—if the object is itself very weakly lighted. When, however, the object is very strongly lighted (brightness above ten candles per square metre, a value never attained with projectors) an increase in the illumination of the adjacent area tends to improve its visibility. One may conclude that a white sky has the effect of diminishing acuteness of vision; however, the illumination of neighbouring objects is too weak to have any prejudicial effect, provided the moon itself does not fall within the direct line of sight. Lateral illumination of the eye of the observer by the searchlight beam may be highly prejudicial to visual acuity, especially if the light is bluish in tint.

for the searchlight a small movable lamp of known candle-power one could alter distance and illumination as in practice. The quantity $\frac{x}{b}$ will be the same for a small model reduced to the n th of the real size as for a real object placed at a distance n times as great. The graph would be constructed as a function of x and $\log E$. (Equation 4.)

GENERAL EQUATION FOR DETERMINATION OF RANGE.

In order to obtain this general equation it will suffice to replace E by the value of the apparent illumination, calculated as above and taking into account the effect of glasses, and to introduce into the expression for visual acuity the magnification, g , which should multiply the dimensions of the object, b .

In this way we obtain the full equation¹:

$$\frac{x_1}{gBb} + H = \log E_1 =$$

$$\log I + (x + x_1) \log a - 2 \log x + \log \left(k \frac{d^2}{p^2} \right)$$

Whence, replacing the last term by R , the final term of the equation, and putting between brackets (since R is always a negative quantity):

$$[R] = \log \left(k \frac{l^2}{d^2} \right)$$

one can write:—

$$\log I = \left(\frac{x}{gL} + H - x_1 \log a \right) + (2 \log x - x \log a) + [R] \dots \dots (6)$$

Two interesting cases may be considered. If $x = x_1$ (as will be the case when both searchlight and observer are on a ship), the second term in the equation is simplified, and we get:—

$$\log I = \frac{x_1}{gL} + H + 2 \log x - x \log a + [R] \quad (7)$$

Again, if $x_1 = 0$ (a condition which occurs when the observer is stationed quite close to the mark, and does not use glasses):—

$$\log I = \frac{x}{L} + H + 2 \log x - x \log a \dots (8)$$

If we assume that a is known¹ the first term within brackets in equation (6) only contains a function of x_1 and the second only a function of x . Tables can therefore be prepared for these two functions in which x and x_1 are assigned various values. If in addition I and the difference $l = x - x_1$ are known the equation determines x .

(To be continued.)

¹ It is to be noted that a being > 1 by definition, $\log a$ is always a negative quantity, the modulus of which shall be represented by $[\log a]$.

LECTURES ON ILLUMINATING ENGINEERING.

WE notice that a series of nine lectures on Illuminating Engineering, by Mr. J. H. Asdell, Mr. S. G. Cranmer, and Mr. R. J. Rogers, has been arranged to take place at the Birmingham Municipal Technical School.

The lectures commenced on Tuesday, February 9th, and are to take place on successive Tuesdays at 8.30 p.m. The syllabus covers both gas and electric lighting, as well as general problems in illumination.

It will be recalled that lectures on Illuminating Engineering were arranged at several educational institutions in London recently, and we are glad to see that Birmingham is also giving practical recognition to the importance of the subject.

The fee for the course is 2s. Full particulars can be obtained from the Secretary, Mr. Geo. Mellor.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

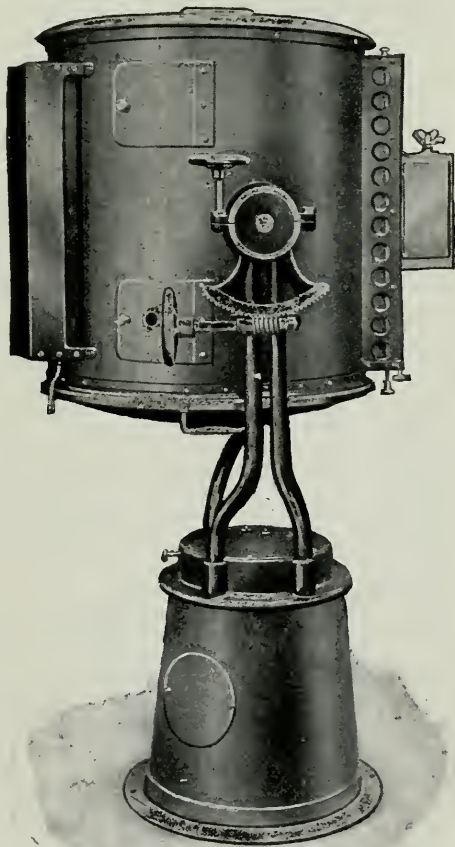
SEARCHLIGHTS FOR ANTI-AIRCRAFT WORK.

At the present time the man in the street finds a new motive for studying the sky by night. Observations of the Heavenly Bodies cannot compare as an attraction with problematical Zeppelins, and the searchlights used for their detection have for him a more than theoretical interest. Anti-aircraft appliances are being studied as they never were before.

The **London Electric Firm** (George Street, Croydon) send us some particulars of a new pattern machine for this purpose, recently added to the other sizes and types of searchlights manufactured by this firm, and now being used for home defence. The apparatus is shown in the accompanying illustration. It utilises a 24-in. silvered parabolic mirror and revolves on ball bearings, enabling a wide sweep of beam and an elevation of as much as 90 degrees to be obtained.

These searchlights are arranged to work on 80 volts or for higher pressures with appropriate resistances.

The special feature of the new lamp is the combined auto- and hand feed, which enables the carbons to be adjusted while the searchlight is in operation. In warfare this is considered an important point; for, should the light be extinguished for a moment, the object on which it is playing (aircraft or warship) can alter its position and make use of the period of darkness to approach closer, rendering necessary a sudden readjustment of the range of defensive guns. For defence purposes, therefore, it is vital that a continuous light, as little subject to interruption as possible, should be obtained.



VERITYS LTD. NEW CATALOGUE.

IN our last issue* we drew attention to a pleasing little booklet on fixtures by Mr. George Verity. We have now before us a more elaborate publication, the enlarged 2nd edition of Vol. III. of the catalogue of fixtures just issued by **Veritys Ltd.** Its compilation must have involved a stupendous amount of work, which, however, is justified by the results. The catalogue contains over 500 pages and sixteen different sections, several of which cover a new field. We find a great variety of brackets, lanterns, chandeliers, ceiling fixtures, &c., most of them executed in traditional styles, others representing the most up-to-date "scientific" methods, and modelled mainly with a view to efficiency. The section dealing with French fixtures is perhaps one of the most complete, though to many the silk-shaded stand lamps will make a strong appeal; an entirely different field is covered in the new "Hospital Section," where practicability rather than ornament is the consideration. The avoidance of the collection of dust is a special point.

The section on indirect and semi-indirect fittings is again an interesting one. It is rather difficult to "place" fixtures of this kind in a decorative series. In principle they are essentially modern, and it is hardly possible to follow tradition to any great extent. And yet these methods of lighting have considerable

decorative possibilities. We notice in the series, bowls of the moulded glass, alabaster, Holophane and other types. What, however, is a distinct novelty is the application of Wedgwood Ware to the semi-indirect system; one would imagine that in many interiors a skilful decorator might obtain some delightful colour-harmonies by combining these fittings with appropriate wall decoration. Indeed, the possibilities in this direction have hardly been sufficiently explored as yet. Another ingenious fitting is the indirect unit shown on p. 93, which can be readily lowered for cleaning purposes.

We are glad to see that the introductory leaflet issued by the company with the volume, besides referring to ornament, decoration and coloured finish, says a word or two on the desirability of screening bright lights from the eye. "Eye-comfort," it is stated, "has been the pass-word for 1914." Over-brilliancy which wearies the eye can never be allied to artistic effect.

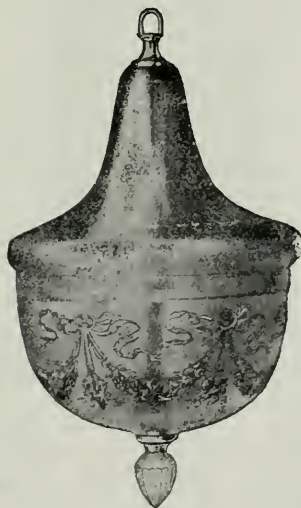
Veritys Ltd. have shown commendable enterprise in issuing this publication in spite of the war and its attendant dislocation, thus giving practical effect to the British maxim "Business as usual." It only remains to be added that the House of Verity, founded in 1819, is British to the core.

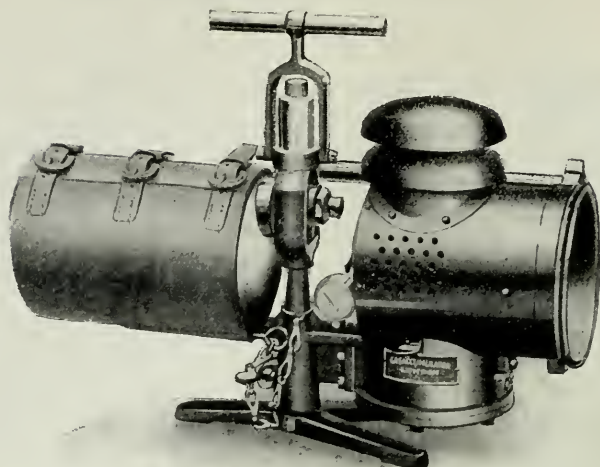
* Jan. 1914, p. 30.



SOME STRIKING VERITYS' FIXTURES.

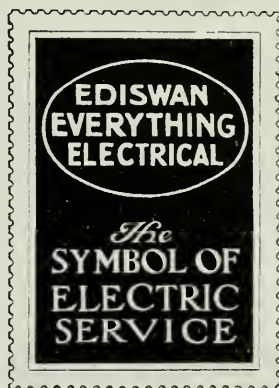
The left-hand upper illustration shows the new indirect fitting capable of being lowered for cleaning purposes; the upper right-hand illustration one of the Wedge-wood Ware semi-indirect fittings; and the third block a three-light etched satin-finished cut glass pendant.





AN ACETYLENE SIGNALLING LAMP.

THE Gas Accumulator Co. Ltd. send us particulars of a compact signalling lamp using a small flame fed by dissolved acetylene. By pressing down a small lever a light (through the lens) exceeding 1400 candle-power is obtained. When the pressure is removed from the lever the flame is cut down to a small non-luminous pilot flame. By alternately releasing and depressing the lever very rapid signalling can take place. This has the advantage over shutter-methods of reducing the amount of gas consumed to a minimum. The whole apparatus only weighs 10 lb. 5 oz., and can easily be carried and used for night signalling by infantry or cavalry.



The above is a reproduction of the Edison poster stamp bearing the well-known motto: "Ediswan, Everything Electric."

We are informed that a contract for the supply of **Royal Ediswan Lamps** for one year has been given by the Orient Steam Navigation Co.

Established
1885.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.

Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES Of Life Assurance, with Various Options.

All Classes of Insurance Business Transacted.

CHIEF OFFICES:

General Buildings, Perth, Scotland.

General Buildings, Aldwych, London.

General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, February, 1915.

	PAGE
Acetylene Searchlights	84
Editorial L. GASTER ..	41
Illuminating Engineering, Summary of Progress during Past Year (concluded)	45
Illuminating Engineering Society—	
(FOUNDED IN LONDON 1909).	
Account of Meeting on January 19th, 1915	51
New Members	52
Searchlights; SOME NOTES ON THEIR SCIENTIFIC DEVELOPMENT AND PRACTICAL APPLICATION P. G. LEDGER ..	53
<i>Discussion</i> —J. Eck—W. M. Mordey—A. Lyon—T. E. Ritchie—F. W. Willcox— L. R. B. Pearce—H. Smith—S. D. Chalmers—Mrs. Hertha Ayrton—A. P. Trotter—C. C. Paterson—J. S. Dow—H. H. Johnson—A. Kitson	
Projectors, Practical and Theoretical Notes on A. P. Trotter ..	82
Projectors, Method of Determining Range of Prof. A. Blondel..	85
Searchlights; SOME NOTES ON THE CONDITIONS DETERMINING CANDLE-POWER AND STEADINESS OF LARGE CURRENT ARCS FOR .. Mrs. Hertha Ayrton	78
Topical and Industrial Section:	
Anti-aircraft Searchlights	91
Veritys' New Catalogue	92
An Acetylene Signalling Lamp	94
Coupon Insurance Ticket	95
Gas Lighting at Haileybury College	96

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL

ACCIDENT FIRE AND LIFE

ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.

GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.

F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that, being dated, forms the only evidence of its currency.

GAS LIGHTING AT HAILEYBURY COLLEGE.

A FEW years ago a considerable number of tests of illumination in schools were carried out by the Illuminating Engineering Society, both in elementary schools and in some of the public schools, such as Harrow and Dulwich College.

The illustration shows the new hall at Haileybury College (near Hertford), which is lighted by gas. The installation consists of a series of 200 c.p. low pressure inverted gas burners, equipped with Holophane 16 in. Reflector-Hemisphere units. The burners are placed at a height of 20 feet from the floor, and



The New Hall at Haileybury College, lighted by inverted gas burners in Holophane Reflector Hemispheres.

The lighting of elementary schools can be standardised fairly easily, as the classrooms are of a more or less uniform size. In an old-established public school, on the other hand, the special nature and purpose of each room lighted needs to be considered, and some ingenuity is often needed to design appropriate illumination for large halls and large interiors.

sixteen of them are employed to light the body of the hall (100 ft. $\times$ 50 ft.).

The photograph, taken entirely by artificial light, shows the results obtained. A good feature is the uniform illumination on the students' desks, and the sources of light are high up out of the direct range of vision.



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.
32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

Fixture Design in Relation to Architecture, Interior Decoration and Illumination.

The paper read by Mr. F. W. Thorpe on the above subject at the last meeting of the Illuminating Engineering Society has given rise to a very interesting discussion.

The question of fixture design and its relation to lighting problems is one in which the architect, the lighting engineer and the fixture manufacturer are all concerned. We have no hesitation in saying that in too many cases the importance of the lighting element in the whole scheme of decoration does not receive the attention it deserves. Although artificial light plays such an important part in the daily life of to-day the amount of care bestowed on the decorative aspects of lighting appliances is probably small in comparison with that given to them in the homes and halls of past ages, when the available methods of illumination were relatively primitive. It is a curious anomaly that some people are willing to expend considerable sums of money on the design of a noble and well furnished interior, and then become unduly parsimonious and indifferent when the method of lighting comes up for consideration ; this applies particularly to many public buildings. Rightly

considered the lighting should form an essential part of the decorative scheme. A well designed unit puts the final touch to an artistic interior ; a crude and imperfect lighting fixture destroys the harmony of the design and prevents the intentions of the architect from being fully realised.

Nor should it be forgotten that in the present age the appearance of a room by night is even more important than in times gone by. When the only available illuminants were the candle and the oil lamp people did not live and work constantly under artificial light as they do to-day. There are many rooms (ball rooms, concert halls, theatres, &c.) which are used almost exclusively under artificial light, and even in the private house it is mainly in the evening that the inmates gather together and have leisure to observe their surroundings. A fixture should therefore be so designed as to be a pleasant object as well by natural as by artificial light. A fixture serves two distinct purposes ; it enables the room to be illuminated so that the surroundings are seen, and it should be in itself a decorative object. The first function is only exercised at night, the second both at night and in the daytime. One can recall instances of delightful metal work which by day is clearly visible, but by night is surrounded by intensely brilliant unshaded lights which prevent its outlines being conveniently seen. Appropriate shading, therefore, is an essential element in successful fixture design.

The decorative value of illuminated glassware, porcelain and coloured silks has perhaps not been sufficiently realised in the past. It must be remembered that the problem has been greatly modified by the introduction of the modern relatively brilliant illuminants—very different from the candles and oil lamps of days gone by. Merely substituting new lamps for old on antique fittings rarely leads to satisfactory results. To bridge the gap between the ancient and the modern often taxes the ingenuity of the fixture designer and the illuminating engineer.

This leads us to say a few words on one of the most debated points in Mr. Thorpe's paper: the desirability (or otherwise) of adhering to old traditional styles when dealing with new illuminants. In the case of interiors of ancient date and historic distinction the problem is undoubtedly a difficult one. Many good judges would agree that it is hardly possible to secure the same artistic results with modern illuminants, as with the oil lamp and the candle, for which the old fixtures were really designed. The conversion of these old fixtures is admittedly difficult in many cases. In some instances it may be preferable to re-design the fitting, still adhering to the period of the interior, but making allowance for the use of modern methods of lighting. The most successful results will usually be attained when the fact of modern illuminants being used is concealed by appropriate shading. For example, there is less objection to the use of electric, gas or acetylene imitation candles with candle chandeliers of the Dutch type, if agreeable silk shades are used ; similarly when electric incandescent lamps or incandescent gas mantles are introduced into antique lanterns, the appearance of the lantern as a whole would probably be better if the nature of the illuminant were concealed by diffusing glass, which modifies its brilliancy and enables the metal work to be more easily seen and appreciated. Unfortunately, if one may judge from the number of cases in which clear glass is employed, there is need of education before consumers can be induced to appreciate this view.

Another question that arises is the desirability of perpetuating the old styles. In this country, where tradition and veneration of a great and

historic past play such a great part in moulding popular ideas, it is, perhaps, natural that there should be a tendency to revert to the styles of the great decorative periods. Yet history shows that the changed conditions of each age do gradually bring about new methods and fresh ideas, and it is probable that the historian of the future will regard some of the recent developments as important transitions in fixture design. To discuss this question in detail would be to enter into the field of the architect and the decorative craftsman rather than that of the lighting engineer. Yet, as Mr. Thorpe has shown, each development in methods of lighting has reacted on the design of fixtures, and it is only reasonable to expect that the incomparably rapid progress of the last ten years will ultimately have an important effect. It must be conceded that the recent advances in gas and electric lighting, and the coming of new systems such as acetylene, incandescent oil, and petrol air gas lighting, have opened up new vista in fixture design and have made possible many departures which would have been out of the question in days gone by. We may even anticipate that the architecture of an age of artificial light will differ from that of days when buildings were considered mainly with a view to their appearance by natural light only. The shape of the modern schoolroom and factory is determined almost entirely by the admission of maximum daylight. May we not expect that some buildings which are mainly used in the evening will be influenced by the provision of the most satisfactory conditions of artificial illumination?

All these are problems which demand the combined efforts of the architect, the fixture designer and the illuminating engineer. Mr. Thorpe has attempted to indicate the varieties of work in which these respective experts will have the predominant control, but in practice it will be found that their work is frequently inter-linked and that their provinces often overlap. The architect, as we have often pointed out, is in a position to render great services to the cause of good lighting and we hope that in the future illumination will assume a more important place in his education. In the higher fields of work the illuminating engineer has much to learn from the architect, and if he is to advise on the lighting of buildings of architectural distinction he should acquire some knowledge of and sympathy with his ideals. In the case of important buildings we see no reason why the architect should hesitate to invite the assistance of an expert in lighting matters; and similarly a lighting engineer might often appreciate the help of an architect who had made a special study of fixtures and the artistic side of illumination. This is an age of specialisation. The general medical practitioner has no hesitation in calling in the specialist, nor does the patient demur at paying his fee. Even so the consumer will eventually recognise that in order to secure lighting conditions in keeping with a noble interior the services of an expert are often well worth paying for.

In what has been said above we have spoken mainly of interior lighting. But the field for enterprise and skill in the lighting of important public thoroughfares and squares and the treatment of the exteriors of public buildings is surely quite as great. Hitherto, it must be admitted there has been little attempt to consider the design and lighting of such areas as one harmonious whole. Town-planning on more scientific lines is rapidly growing in importance and should occupy an even more distinctive position at the close of the present war. Is it too much to hope that in the schemes of town-planning that are now on foot, the claims of orderly and artistic public lighting will receive a fair share of attention?

Illuminating Glassware : a National Industry.

Illuminating glassware, it may well be said, will play an important role in the fixture design of the future. With modern powerful illuminants the consideration of the best methods of shading and distributing the light goes hand in hand with the design of the metal work by which they are supported. In many cases, it is not too much to say, the design of the fixture is to a great extent controlled by the nature of shades, globes or lanterns which it is intended to carry.

During the last few months it has come to many people as a surprise to find how greatly we are dependent upon foreign-made glassware for the maintenance of the lighting industry. There are exceptions, and we can recall one firm that manufactures scientific and decorative glassware of a high standard in this country. But the great bulk of the material is imported from abroad.

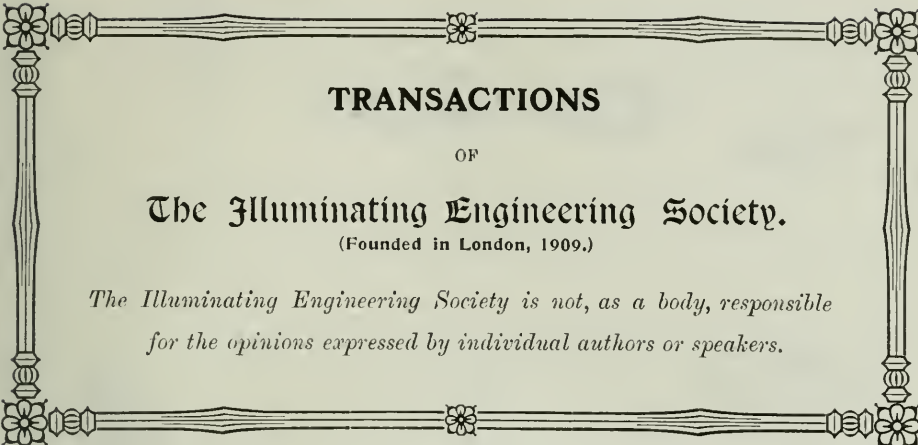
To the lighting industry this is highly unsatisfactory. In times of war supplies are greatly impeded and business is dislocated. In times of peace, when the supply is abundant, we have nevertheless been dependent mainly on the glassware designed by others, and our own efforts are accordingly influenced by whatever models are introduced from abroad. The ideal development of decorative art in connection with illumination would surely involve the capacity to make and design our own glassware in sufficient quantities; and it should be our pride, not to follow, but to lead the rest of the world.

Those who have studied Continental methods, who know the long experience and patient research that has largely enabled other countries to gain this supremacy, realise the difficulties in developing the industry in this country on a similar scale. Yet there is before us a great opportunity. Isolated efforts by small individual glassworks will not make this a national industry. But by co-operation on the part of the leading companies interested, and by the full utilisation of the scientific and technical skill of the country, such an industry might be established.

Unprecedented situations demand new methods. Already the gigantic step of establishing a national dye industry is being undertaken. Be the results what they may, it is an enterprising and praiseworthy effort. The glass industry is, to our mind, another instance of the need for national support. Besides glassware for illuminating purposes there are many sections of the industry, such as the manufacture of glass for optical and chemical work, of equal importance. Such glass is a valuable element in the construction of many scientific instruments and not a few munitions of war. In the glass industry there is surely another opportunity for co-operative effort.

We would like to add, what is common knowledge among those interested in this industry, that the organisation of the labour employed is as vital to success as the consolidation of the resources of those controlling glass manufacture. We venture to suggest that an exhaustive inquiry should be instituted by the Government into the causes which have contributed to hamper progress in years gone by, with a view to securing—if necessary by radical alterations in the labour conditions and other matters—the placing of this industry on a more satisfactory basis in the future.

LEON GASTER.



TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

*The Illuminating Engineering Society is not, as a body, responsible
for the opinions expressed by individual authors or speakers.*

SOME NOTES ON THE DEVELOPMENT AND DESIGN OF LIGHTING FIXTURES IN RELATION TO ARCHITECTURE, INTERIOR DECORATION, AND ILLUMINATION.

Proceedings at the Meeting of Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m., on Tuesday, February 16th, 1915.

A MEETING of the Society took place on Tuesday, February 16th, as stated above, Mr. Frank Bailey being in the chair.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of new applicants for membership as follows :—

Honorary Member :—

Edison, Thomas Alva Orango, New Jersey, U.S.A.

Ordinary Member :—

Young, Stanley

Engineer to The Automobile & Electrical Equipment Co.

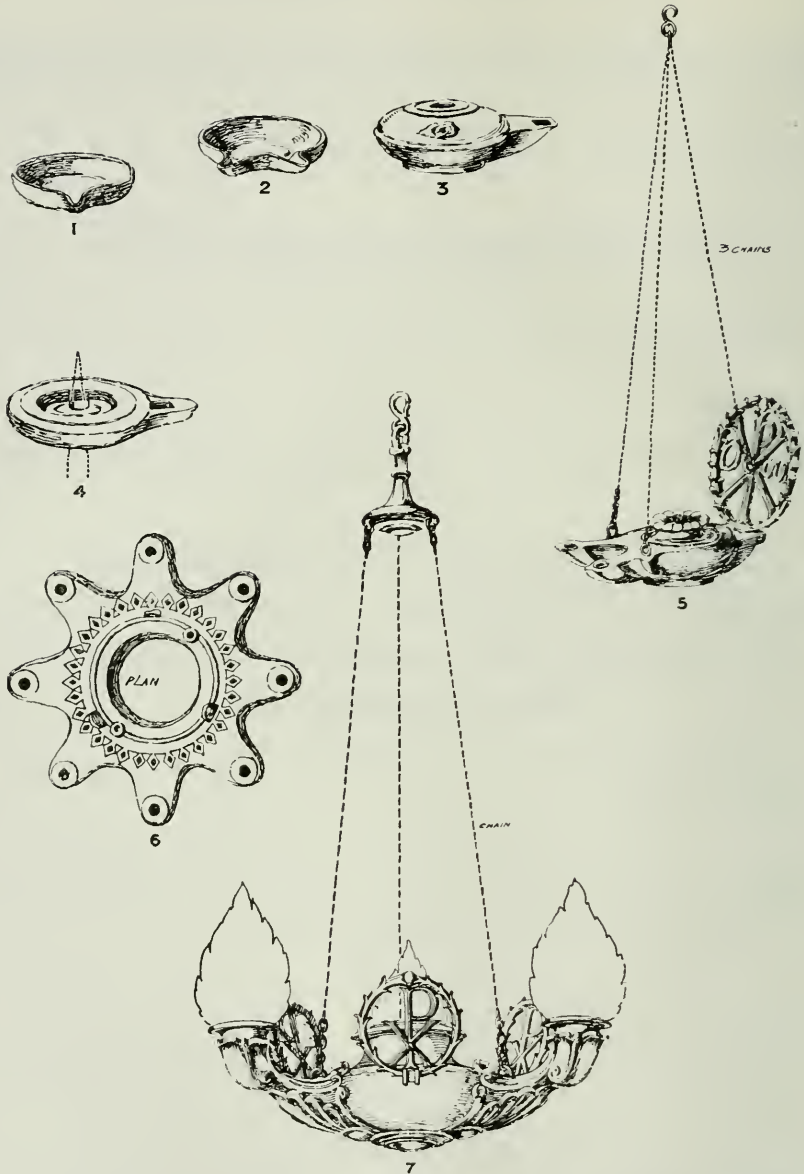
The names of applicants announced at the previous meeting on January 19th, were read again, and these gentlemen were formally declared members.*

The CHAIRMAN then called upon Mr. F. W. Thorpe to read his paper on "The Development and Design of Lighting Fixtures in Relation to Architecture, Interior Decoration, and Illumination," and a discussion took place in which the following took part :—

Mr. J. DARCH, Mr. A. P. TROTTER, Mr. E. P. WARREN, Mr. P. J. WALDRAM, Mr. C. H. BURT, Mr. J. G. CLARK, Mr. PERCY MARKS, and Mr. A. E. PENN. The HON. ASSIST. SECRETARY also presented a communication from Mr. W. D. HELPS.

In conclusion the CHAIRMAN called for a vote of thanks to Mr. Thorpe for his paper, and announced that the next meeting of the Society would take place on March 16th.

* *Illum. Eng.*, Lond., Feb. 1915, p. 52.



INFLUENCE OF ANTIQUE BOAT LAMP ON MODERN DESIGN.

FIGS. 1 & 2.—Simple Greek lamps in pottery, 5th and 4th century B.C.

FIG. 3.—Earthenware lamp. Roman occupation of Britain. Found in London.

FIG. 4.—Earthenware lamp, with hole in centre for fixing on spike. Roman occupation of Britain. Found in London.

FIG. 5.—Bronze lamp found in the catacombs at Rome and ornamented with the sacred monogram.

FIG. 6.—Eight-light earthenware lamp. Roman occupation of Britain.

FIG. 7.—Modern bronze boat lamp, based on Fig. 5, in the Jesus College Chapel, Dublin.

SOME NOTES ON THE DEVELOPMENT AND DESIGN OF LIGHTING FIXTURES IN RELATION TO ARCHITECTURE, INTERIOR DECORATION, AND ILLUMINATION.

By F. W. THORPE.

Paper read at the Meeting of Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 5 p.m., on Tuesday, February 16th, 1915.

IN this paper it is proposed to deal briefly with the development of lighting fixtures and to show their importance in the decorative scheme. The paper has been written mainly with a view to opening the discussion on this subject.

It is hardly possible to give a very detailed account of the many styles of architecture and decoration. So much thought and care has been devoted by successive generations to bring these styles to perfection, that it would necessitate a life's study to master even one of them completely. Modern architects and designers often excel in one style only, showing considerable skill and individuality in associating old forms and details with modern requirements. In the latter part of this paper some general problems applying to fixture design as a whole will be dealt with, and instances will be mentioned in which the co-operation of the architect, the fixture designer and the illuminating engineer is required.

There are so many sides to the subject that the arrangement of the matter in such a paper as this in itself presents considerable difficulties. The best method seemed to be to begin by taking the lighting appliances from the antique onwards, and before proceeding to the discussion of modern practice, to trace the fixtures for various illuminants in use from ancient and mediæval times to the development of the gasolier and electrolier and other types now possible but impracticable in the past. This method will help us towards the better comprehension of the development of lighting fixtures, for the modern is the outcome of these old ideas. The fixtures designed in old and historic styles were intended to carry candles and oil lamps ;

but those of the present day, besides carrying the lamps, have also to provide access for the "fuel," i.e., provision must be made for the working into the design of tubes conveying gas or electric wires. This alone, apart from the difference in the illuminant itself, has naturally had a material influence on the design of modern fixtures.

Let us begin therefore with the oldest civilisation, the Egyptian, with whom the story of architecture may be said to have commenced. Following them came the Assyrians and Babylonians, and then the Greeks, whose architecture and sculpture was such as might be expected from a highly civilised and refined people, and greatly influenced succeeding Art. The Romans developed their style after the Greek. In the Eastern Roman Byzantine Empire, Eastern influence played a great part, and with the overthrow of this Empire the Mohammedan Art developed.

The invasion of Italy by the Northern Tribes saw the decline of classic Art, which developed into Romanesque, and from Romanesque into Gothic, widely adopted throughout Europe. But this in turn was supplanted by the Classic Revival (the Renaissance) in Italy, which likewise influenced strongly all European Art.

Each country developed the revival after its own ideas. Subsequently, individual designers, such as the Brothers Adam, Chippendale, Sheraton and others, were successful in forming styles peculiar to themselves, both in architecture and furniture and interior decoration. The periods connected with the Renaissance in England are those with which we have mainly to conform in modern installations.

THE INFLUENCE OF EARLY LAMPS ON MODERN FIXTURES.

As artificial light became general with the advance of illuminants, the importance of the lighting fixture as a decorative object was recognised, culminating in the candelabra produced during the Italian Renaissance and the 17th and 18th century French periods, now models for most countries, and which many people consider have not since been excelled. As new illuminants appeared the nature of these fixtures was influenced, yet in many cases the original forms were retained. When twentieth century illuminants are used the question must, however, arise whether some of these old models can be properly adapted to the new conditions.

The adaptability of some of these to modern methods is nevertheless illustrated in some of the following plates, where examples of the old and new forms of fittings, both in the same distinctive style, are reproduced side by side. The simple "boat lamp" of the ancients, and also the *crusie*, *rush* and *tinder-holder* were subordinate to other articles of furniture, for we may safely assume that in these days artificial light was avoided when possible, and therefore the fixture did not receive the attention or occupy such an important position as the lighting fixture of to-day. Yet, whereas the antique lamp often surpasses the modern lamp in its artistic qualities, it was invariably defective from a purely utilitarian standpoint; the modern fixture on the other hand, although more efficient, seldom reaches the antique standard of beauty.

The boat-lamp was in use for centuries and is in use even at the present time in remote parts of the East; those made during the best periods of Greek Art are often beautifully proportioned and modelled with mythological decoration; they were mostly of pottery for a single burner, sometimes, however, for two, and occasionally for as many as ten. They vary in size from two to six inches in diameter, the majority being about three inches.

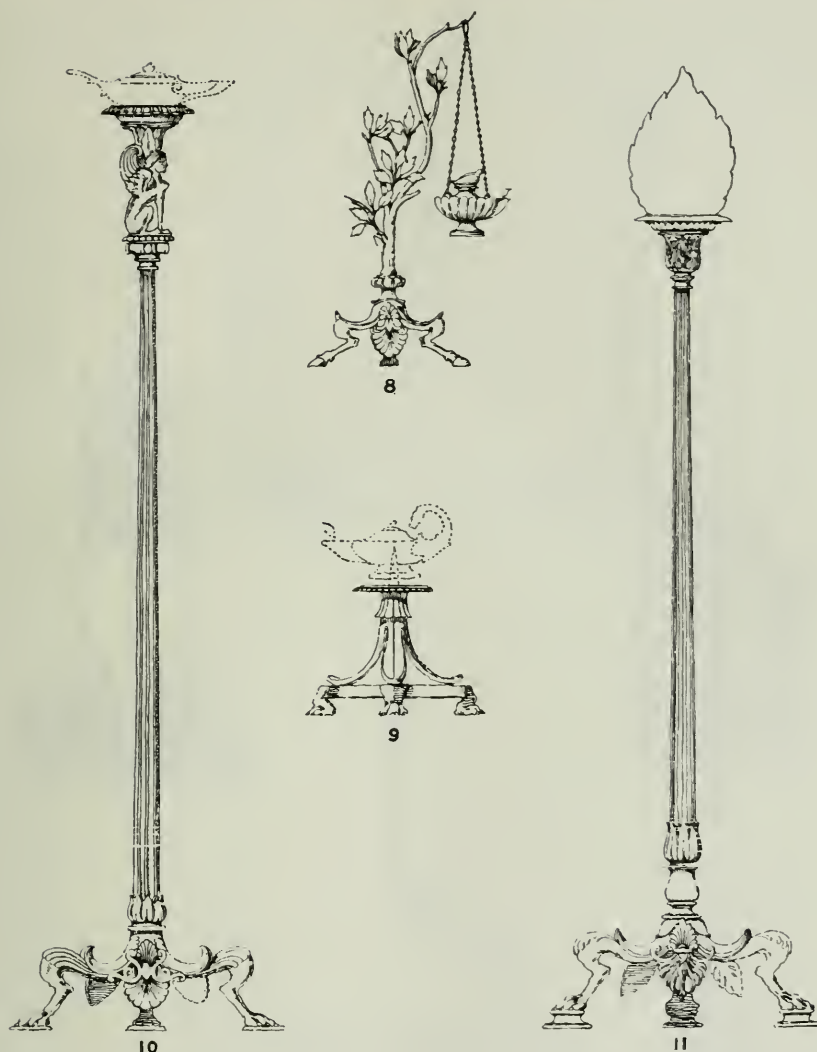
The Roman lamps were often of bronze with much more variety of design. Lamps in the form of the human foot or a bull's

head may be seen in the British Museum. From the beginning of the Christian era they were usually decorated with views of Biblical scenes and symbols having a religious significance, replacing the Græco-Roman mythological ornamentation. Lamps of this kind were used for ordinary domestic lighting. They were also commonly deposited in tombs or kept burning at the shrines of martyrs, thus showing even in these ancient days the symbolism of light, used for religious and ceremonial purposes. The Romans, as might be expected, introduced the boat lamp into England, and several have been excavated. They are, however, seldom of bronze, and almost invariably in earthenware, with a small projection at the side for a handle. They were often placed in small earthenware trays in order that any spilled oil would be collected. These lamps are crude in comparison with those produced in Rome at the same period. The shape of the antique boat lamp was revived during the time of the Renaissance, again during the French Empire period, and is being revived once more in harmony with the prevailing style of Neo-Greek architecture.

LIGHTING FIXTURES BASED ON ARCHITECTURAL AND DECORATIVE PERIODS.

The design of the lighting fixture has always been contingent upon architecture and decoration for their form and detail of ornament. Conventionalised natural forms, such as a branch of foliage, were often used by the Romans; in some instances the human figure and animal forms were used as a basis for the enrichment of the shaft.

In this way the candelabra was developed and came to occupy an important place in their domestic and religious life. The Romans were luxurious in the furnishing of their homes, and bronze candelabra were amongst the finest objects of furniture. The slender bronze models, of which a few shapes seem to have become standardised and made in great numbers, were mostly for domestic lighting, being made, like the modern electric standard, in two sizes for use on the table and the floor. The large marble candelabra were for



THE INFLUENCE OF THE ANTIQUE CANDELABRA ON MODERN DESIGN.

FIG. 8.—Græco-Italic lamp standard for suspended lamps, in bronze.

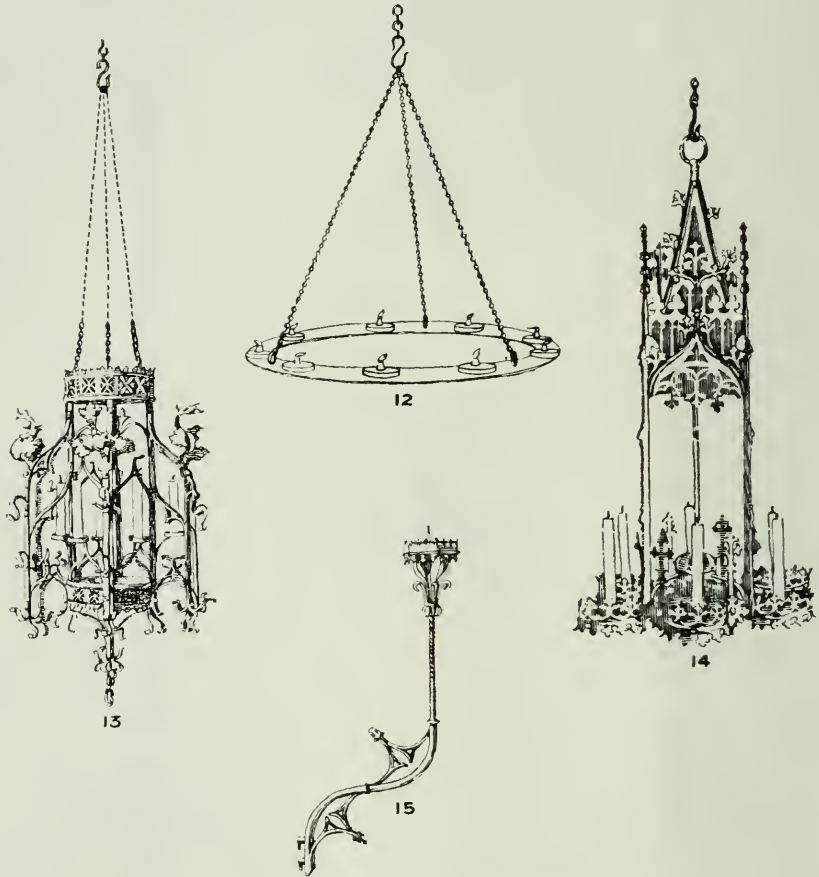
FIG. 9.—Antique bronze lamp-stand with spike fitting into bottom of lamp which can be used as hand-lamp and standard.

FIG. 10.—Antique candelabrum (Museum, Naples).

FIG. 11.—Modern electric standard based on antique. (From the Haymarket, London.)

religious and State ceremonial purposes. The bronze models invariably used had a flat capital upon which the boat lamp was stood. In some cases the stand terminated in a spike or projecting arms

rigorous conservatism to modern requirements, their importance and correctness in the decorative scheme, often outweighing their practical utility as a lighting appliance.



ECCLESIASTICAL FIXTURES.

FIG. 12.—Form of fixture used in early Christian basilicas. (From *Illum. Eng.*, N.Y.)

FIG. 13.—Medieval wrought iron fixture for several candles.

FIG. 14.—Iron-traceried fixture for candles, 15th century.

FIG. 15.—Wrought iron fixture, French, late 15th century.

from which lamps were suspended. All these models afford excellent material on which to base modern designs and their frequent use by architects of the present day is justified by their beauty of design and proportion.

Reproductions of candelabra designed and produced by master craftsmen of the past are often adapted with a

ECCLESIASTICAL FIXTURES.

It has been remarked that the candelabra mentioned above, besides being important objects in the home, played a part in the religious ceremonial of the ancients, as it does in many of the cathedrals and churches of the present day.

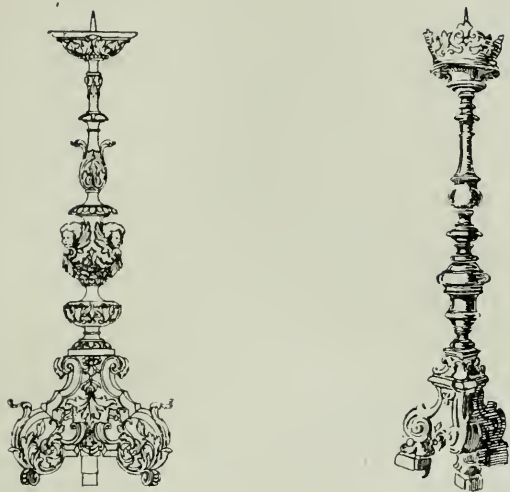


FIG. 17.— Renaissance candlesticks.

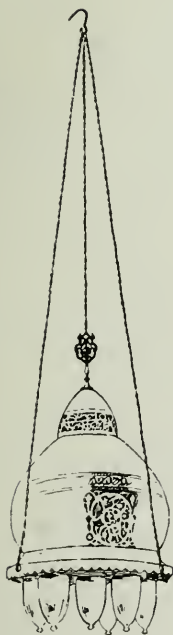


FIG. 16.—Lighting fixture from an Eastern Mosque, dome pierced all over.

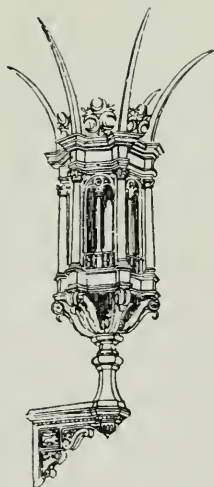


FIG. 18.—Palazzo Strozzi lantern.
(Renaissance.)

In the modern lighting of places of worship to-day we must uphold conservative treatment, remembering the importance of tradition in Ecclesiastical Art. Forms, sometimes symbolic, have been in use for centuries. We trace the plan of the modern church to the Early Christian basilica of the East. The various styles of church architecture from the Byzantine, the Art of the Christian East to Romanesque, the transition from antiquity to the Middle Ages, and to the Art of the Christian West, Norman, Early English, Decorated and Perpendicular Gothic—have all given rise to characteristic types of lighting fixtures of remarkable beauty of design and craftsmanship.

Churches are designed on traditional lines, and embody the individuality of the architect. Modern improvements, such as lighting fixtures, should form an essential part of the scheme and must be in harmony with the original design.

The fixtures of the Mohammedans, used in the lighting of the Eastern Mosque, are often of the familiar dome type. In the Middle Ages Persia became the most brilliant centre of Saracenic Art; which, travelling westward with the conquests of the Moors, left its influence upon the shores of the Mediterranean, especially in Southern Spain. The influence of architecture on lighting fixtures is here apparent, for the lamps are most shaped like the dome of a mosque, from the base of which are suspended glass cups containing oil and wick; their chief characteristic is a profusion of geometrical forms and conventional foliage. The workmanship of these lamps is to the Western mind wonderful, entailing considerable labour and skill. They make liberal use of the embellishment of damascening (one metal inlaid into another) and piercing so that when illuminated the piercing is seen in silhouette. (This is interesting as an early instance of deliberate use of artificial light for decorative effect. These fixtures only appear at their best when the silhouette effect, due to the artificial light, is produced.)

During the Italian Renaissance, the candelabra were revived along with the tradition of antique art; old forms were adapted to changed ideas. From this

time onwards candelabra appear in many different types and made in various materials, the finest examples of which are to be found in the churches of Italy. On these models the majority of modern church candelabra are based.

The architects of the Renaissance made full use of the lighting fixture in the embellishment of the exterior and interior of the churches and palaces of Italy. The lantern bracket outside the Strozzi Palace at Florence surely adds interest to the building.

FIXTURES FOR DOMESTIC LIGHTING.

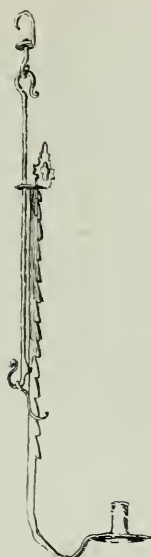
Except in the mansions of the great the progress of illumination in the homes of the middle ages was comparatively slow, just as the methods of illumination were extremely primitive. But from Tudor times onward, although means of illumination were still limited, there was constant change in the type and style of the lighting fixtures. Style succeeded style in waves. New ideas were grafted to the old, and gradually superseded them as they apparently reached the limit of development.

The various countries developed their own art according to environment and temperament, and eventually evolving styles peculiar to themselves. In England, for instance, the furniture relied upon boldness of form rather than colour for effect. This was the age of oak, and ornament was still of an architecturally Gothic character. The iron rush and tinder holders used in domestic farm and cottage lighting of this date include many ingenious contrivances, some possessing distinct artistic merit.

Architects and designers in endeavouring to preserve in their reproductions of various rooms the atmosphere and spirit of the period require to be correct in regard to the gas or electric light fixture quite as much as in other details of furniture. Hence, if a room is to have the correct Early English atmosphere it is necessary to adhere to the correct old forms. This atmosphere is, after all, only obtained in the decoration; the fixtures are added to and regarded as furniture, and are primarily of æsthetic value owing to their shape and the colour-harmonies they make possible



19



20



21



22



23

**ENGLISH IRON DOMESTIC LIGHTING FIXTURES,
17th AND 18th CENTURY.**

FIG. 19.—Floor light with rush holder and wood base. Four feet high, adjustable up and down stem.

FIG. 20.—Suspension fixture and adjustable ratchet for candle.

FIG. 21.—Floor light with candle holder, adjustable on stem, wood base.

FIG. 22.—Table rush and candle holder with wood base.

FIG. 23.—Iron Scotch lamp (crusie) for oil.

(bright iron against oak, &c.). Because the illuminant is modern the resultant effect, with due consideration, need not be incongruous. In a modern room possessing decorative qualities, if it is not the aim of the owner to be correct in detail, any type of lighting fixture can be employed so long as it is in good taste.

In Mid-Tudor and Stuart times the Renaissance in Italy began to make itself felt in England. Italian ornamental details were grafted on to Gothic forms, often with pleasing results. Again, the close connection between the English and Dutch courts was the means of introducing new ideas into furniture, which depended upon colour as well as form for effect. (The effect of colour as applied to lighting will be mentioned later.) This, again, had its effect upon the accessory arts, and is noteworthy as leading to the introduction of the Flemish candelabra, perhaps the most popular of all lighting fixtures at the present day. Generally speaking, these chandeliers are in harmony with any classic room, being frequently used by Sir Christopher Wren (17th century) for the decoration and lighting of the old city churches. There appears to have been such a deep-rooted liking for these old candelabra that they have been used in turn for candles, flat-flame gas and incandescent gas burners, and later for imitation candles using gas, acetylene and electricity. It must be owned that the effect of such candles, equipped with suitable shades, is invariably pleasing, and the shades have the effect of concealing the actual light and disguising the fact that a modern illuminant is being used.

Inigo Jones was, perhaps, the first English architect to design on classical lines without Gothic influence. Succeeding architects all took up the classical Renaissance (which is, broadly speaking, a return to the best periods of Greek and Roman Art, 500 B.C.—300 A.D.).

From this revival sprang the classic revival in furniture and interior decoration in England and France. Chippendale, the brothers Adam, Sheraton, and Hepplewhite were designing furniture each in their distinctive styles with which we are familiar. In France the

Louis XIV., XV., XVI., and Empire styles for which the French are so famous were influencing the decorative art of the whole world. The candle, as we know, was the illuminant with which these designers worked. All of them aimed at design of fixtures in harmony with the furniture and scheme of decoration. Chippendale, who worked in St. Martin's Lane, also designed many lanterns and girandoles to harmonise with his furniture, in the designs of which we trace the influence of French art.

Chippendale eventually went out of fashion, the Adams style coming into favour. The furniture became lighter in character and more classic in design. Sheraton and Hepplewhite followed, and we come then to the Victorian era, which is generally regarded as showing a great deterioration in style. At the present time designers in general follow some traditional style, and the changed circumstances of this industrial age somehow do not seem to favour the creation of new distinctive styles.

In what has been said above the author has only tried to illustrate a few characteristic periods of design, and to sketch very briefly the general course of progress since the early days of artificial illumination. There have been, of course, countless other styles on which much could be written; for instance, the wonderful creations of Japan, with their colour-harmonies in paper and silk, which seem to lend themselves particularly well to use with artificial light.

In the remainder of the paper it is proposed to discuss some of the problems that are of interest to architects, fixture designers and lighting engineers of the present day.

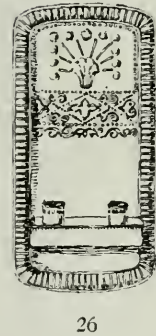
VARIOUS PHASES OF INTERIOR LIGHTING.

A broad distinction may be drawn between domestic and public lighting. In the former individuality can be shown in the selection of fixtures, and the purchaser is free to follow his personal desires. In the case of public lighting (by which not only the lighting of the streets, but of halls and rooms, belonging to or habitually used by the public may be understood) novelty in design or system is not

desirable, an efficient lighting scheme, supported by fixtures well adapted to the architecture, is the chief requirement.

It is difficult to lay down definite rules as to the method of lighting best adapted for various rooms, every architect will

relative decorative values. The fixture should be considered in effect as well as efficiency. Generally speaking, a hall room demands an effect of gaiety, a dining room comfort, and a library an air of repose—all of which conditions



DUTCH.

FIG. 24.—Six-light fixture in the Burgomaster's Room, Town Hall, Haarlem.

FIG. 25.—Modern fitting designed for the modern lighting of Sir Christopher Wren's Chapel, Greenwich Palace, showing Dutch influence.

FIG. 26.—Hand-beaten brass sconce for two candles, Dutch, early 18th century. The back plate, highly polished, acting as a reflector.

have a different idea, and lighting requirements vary so much with the nature of the building, both in the amount of illumination and the effect desired. Care must be taken in the selection of the system, for we consider the relative efficiency of the direct, semi-indirect, and indirect principles, but often forget their

may be secured by the judicious selection of fixtures, strength of illumination, and use of colour. These considerations have been dealt with from the lighting standpoint, but not the decorative, in several papers before this society. There are certain general requirements should be fulfilled, whether we are dealing with

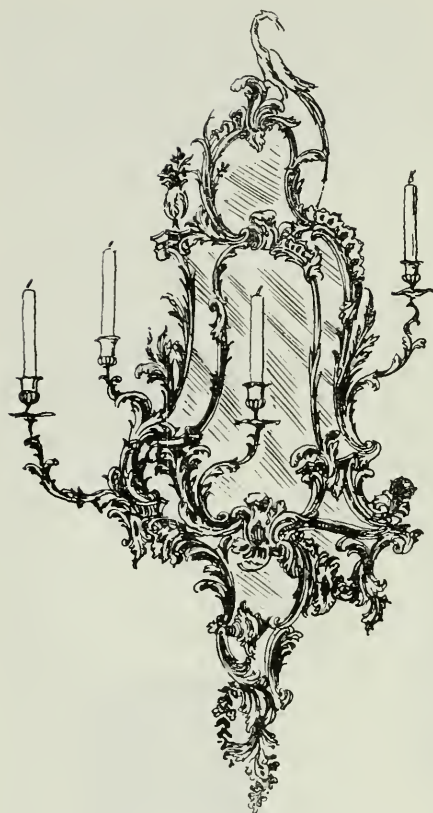


FIG. 27.—Chippendale Girandole, middle 18th century.

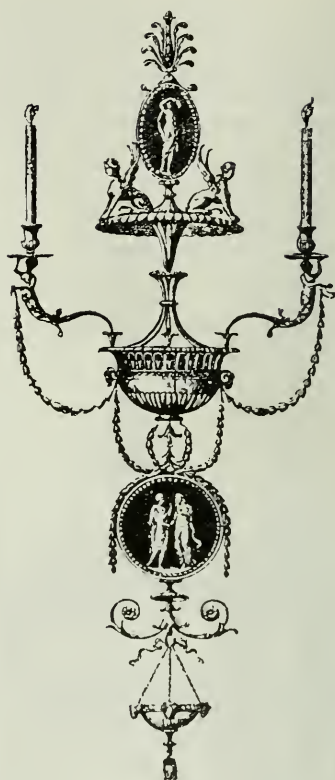


FIG. 28.—Girandole by the brothers Adam in the Etruscan room at Lord Derby's.



FIG. 29.—Hepplewhite fitting.

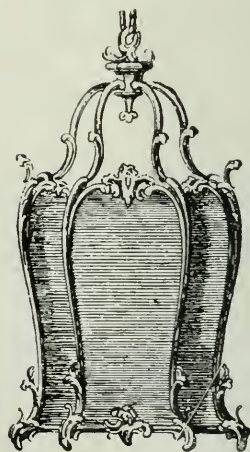


FIG. 30.—Chippendale Lantern.

ENGLISH EIGHTEENTH CENTURY.



FIG. 31.—Reproduction of a sconce designed by Daniel Morot. Period Louis XIV.



FIG. 32.—Candelabrum. Period Louis XV.

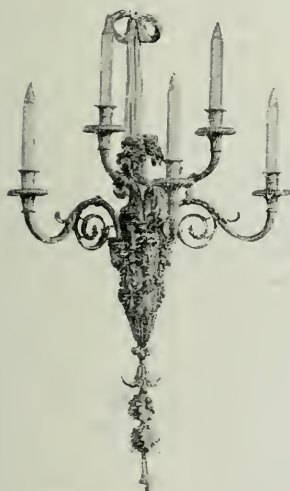


FIG. 33.—Candelabrum from the Petit Trianon. Period Louis XVI.



FIG. 34.—Caryatid Bracket. Empire period.

FRENCH.

an old interior or a modern room. One of the most important of these is the choice of appropriate glassware or shades to go with the fixture. On entering a room lighted by artificial means the natural tendency is for the eye to travel involuntarily to the brightest object. One not infrequently finds good metal work in combination with unscreened lamps or mantles giving a glaring effect and hard shadows, such as are not desirable from a practical standpoint and are usually out of harmony with the æsthetic claims of the room. Broadly speaking, lighting that is inconvenient to the eye is also inartistic. In the past, artificial illuminants were invariably of low brilliancy. The candle and the oil-flame had a brightness far less than that of the incandescent filaments and mantles of the present day and the tendency of tradition is therefore towards soft and moderately bright effects.

The correct shading of artificial illuminants should therefore be considered in connection with fixture design. In some cases it may be said that the best lighting is unobtrusive. There are instances in which the illuminated surroundings constitute the vital point of interest and it is preferable not to have one's mind distracted by speculations as to the origin of the artificial light illuminating them. But in many other cases the light source may be made an essential part of the scheme of decoration. A fixture equipped with pleasantly shaped and coloured shades adds considerably to the decorative value of the room both by night and day. Fixtures are apt to be considered too exclusively from the standpoint of their appearance in daylight. At night-time, when they fulfil their useful function of illuminating the room, their appearance should also be pleasing. Care must therefore be exercised to ensure that the artificial illuminant does not distract the eye in following the lines of the fixture. One meets many cases in which the great brightness of a lamp placed within a clear glass lantern makes it impossible to see the metal work; in the daytime one sees the outline clearly, but when illuminated one no longer sees the fixture but only the source of light—by no means a decorative object. One may therefore lay stress

on the importance of decorative silk and glassware in the scheme of lighting. There are instances in which the desire to be correct to period makes it impossible to use diffusing globes and bowls now becoming so common, but they certainly have an important rôle to fulfil. In passing one may refer to the disturbance in the glass industry caused by the war. It is well known that most of the fine examples of glasswork come from abroad. The difficulties of establishing such an old-established industry in this country are doubtless great, but not insuperable.

Strictly speaking, the use of an electric lamp or incandescent mantle in an Adams, or Tudor, interior, may be considered an incongruity. But the incongruity is lessened if the modernity of the source can be concealed. Thus electric candles can be used with silk shades, and it is difficult to find a prettier effect. Modern illuminants can be used with antique lanterns if diffusing glass is employed to screen the lamps from view. The white glass bowls used occasionally with Flemish features are admirable in this respect, since they can be used with any illuminant, electric, gas, acetylene, etc., concealing the source and giving a soft illumination of the semi-indirect type. By such methods various old models, where desirable, can be adapted to the requirements of modern illumination.

FIXTURES FOR PUBLIC LIGHTING.

Much that has been said applies both to domestic and public lighting. But in the latter case the claims of good lighting from the decorative standpoint are particularly pressing. A fine public hall, a church, a museum—buildings that are frequented by the general public—deserve illumination in conformity with the architectural scheme. In a private house defects of taste are perpetrated by the individual; but the conditions in public buildings reflect the artistic sense of the nation.

The lighting of such buildings is too frequently neglected. There is a tendency for the illumination to be considered at the last moment, when the building is almost complete, and the money set apart for its adornment almost exhausted. Not infrequently the lighting is handed

over to the contractor at the last moment, and he receives few instructions except those that have reference to economy. Cases could be mentioned of public buildings where the interior is impressively designed and lavishly decorated, but the fixtures are of the crudest description and have no relation to the general scheme of the building, although the illumination may be considered good.

To the architect it should be a matter for concern how the interior designed by him is lighted. Now the conditions are entirely different from those that prevailed in the past when artificial light was in a primitive condition and the use and appearance of buildings by artificial light was not contemplated to any great extent. But in the present day there are many buildings where this condition is almost reversed. It is difficult to comprehend, when one remembers the care and thought expended in the adequate natural lighting of a building, why the artificial lighting should not always receive the same attention.

It is therefore essential not only that good and suitable fittings should be designed under the architect's supervision, but that these fixtures should be placed in the right positions and give the correct illumination. Upon this depends the whole success of his efforts as far as night time is concerned. The harmony of his scheme may be wrecked by tawdry and incongruous fittings. The amount of light to be given to each portion of the room needs to be very carefully considered. The position of fittings should be decided at an early stage in the design of the building, thus obviating the frequent practice of placing brackets on the centre of good columns, or over mouldings, spoiling the architectural scheme instead of adding to its effect. The positions of chandeliers is usually fixed by the nature of the outlets provided on the ceiling, and their practical utility in these positions, as well as their part in the decorative scheme, needs to be considered. One could mention cases in which the use to which the room is to be put has not been sufficiently considered; chandeliers have been fixed at points such that the utmost ingenuity of the lighting engineer failed to achieve a proper distribution of light.

It is beyond the scope of this paper to deal with specific problems in lighting, but one type of building—the church—deserves special mention. There are those who consider that in churches of historic and national value the atmosphere should be preserved by retaining old fixtures and illuminants. This is an arguable position, but as a matter of fact the introduction of modern illuminants, at first vigorously opposed, almost invariably comes to pass sooner or later. But it is curious to see that in many such cases the new illuminant, when it is introduced, is employed with little technical skill, and without any serious attempt to grapple with the complex problem of using new illuminants and fixtures in old surroundings. There are, perhaps, few problems in lighting that present such varied aspects. Besides considering the architecture one has to bear in mind the practical points involved in the needs of the worshippers; in large mosques and cathedrals, where the service is mainly carried out by the priest or choir, the congregation do not need so much light as in a modern English church where they take an active part in the proceedings.

Even in those cases in which the lighting has been considered with some care, one often finds a curious neglect of period. For example, while the lighting of Westminster Abbey may be good, the modern fixtures are not in keeping with the architecture. They are not Gothic, but have a strong Dutch influence. Those installed in Liverpool Cathedral are perhaps not so efficient as lighting units, but they are certainly in harmony with the architecture of the building.

Before leaving this part of the subject a word or two may be said as to the part played by fixture design in exterior lighting. It is a remarkable fact that, while people will spend considerable care on the artistic side of interior lighting the possibilities of outdoor illumination have scarcely been considered. Lamp-posts are erected bearing no relation to the surrounding architecture. Now in the case of existing squares and streets, which have grown up more or less chaotically, there may be difficulties in obtaining a coherent scheme. But

in the planning of new streets and squares and town-planning is a science that is attracting much attention to-day—the lighting and the architectural scheme of streets and squares should surely be planned simultaneously so as to form one harmonious whole. There have been a few attempts to design special lamp-posts. A fine model was worked out some years ago by the Royal Academy, and so far as the author is aware the design has not been duplicated. The original model was presented to the Office of Works and now occupies a somewhat forlorn position in the Horse Guards Parade. Another instance of good design is the bronze standards in The Mall. Lamp-posts are usually purchased by the borough engineer. It would be desirable for the designs to be first submitted to an architect.

There are also possibilities in the treatment of fixtures attached to the frontages of buildings, which should be designed to conform with the architecture. Again, the electric sign need not be the hideous object which architects rightly condemn. How often do we see and admire fine modern buildings—when the scaffolding is removed, and the work of the architect and the decorative craftsman are revealed—only to find that with the entrance of the tenant a large electric sign makes its appearance, sometimes placed right across the building, spoiling proportion and often hiding good ornament. This happens in the case of almost every theatre and place of amusement erected. We cannot blame the owner, who intended all along to have such a sign, nor the electrical contractor for persuading him to have one. A solution would be for the architect to design a space for the sign, in the same way as one is left for the fascia of a shop. This may present architectural difficulties in some cases, but as a rule they could be overcome by co-operation, at the proper stage, between the architect and the electrical engineer.

THE INFLUENCE OF LIGHT AND COLOUR ON DECORATION.

It has already been pointed out that the fixture is an important part in the scheme of decoration. But besides this

function the lighting unit has the effect of illuminating surrounding decorations and enabling them to be appreciated. The nature of these decorations should, therefore, have an influence in determining the scheme of lighting to be adopted. For example, if a hall has a very ornate ceiling and frieze, it is not a satisfactory plan, from the decorative standpoint, to use fixtures which concentrate nearly all the light downwards, leaving the ceiling and frieze in semi-darkness.

The part played by colour in furniture has been mentioned, but the possibilities of colour have been neglected in modern fixture designs. The absence of colour is sometimes considered a drawback to indirect lighting for domestic use: semi-indirect and direct offer more scope by the simple use of coloured material to screen the light. The old-fashioned tent dining-room light would have been abandoned long ago were it not for the colour effects to be obtained. The selection of colours in the lighting appliance to harmonise with the walls and furniture in a room offers scope for considerable ingenuity and taste.

MODERN DEVELOPMENTS.

The above remarks lead one naturally to speak of some modern developments in fixture design. In this paper the architectural and decorative aspects have been mainly discussed, but it must not be forgotten that there is a practical side. Of late years a great deal of attention has also been devoted to the design of fixtures with a view to the distribution of light in the most efficient manner, and in many cases entirely neglecting the artistic standpoint.

It must be admitted that several types of fixtures designed on traditional lines, and perhaps based on old models, are not particularly efficient as distributors of light: the metal work leaves little to be desired, but the arrangement of lights, shades and reflectors are often inefficient.

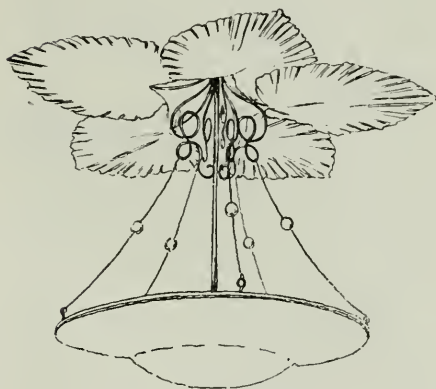
For the lighting of modern rooms the scientific as well as the artistic design of fixtures is of considerable importance, and the requisite distribution of light, together with the desired artistic qualities, can be obtained with these old models

if arranged to meet modern requirements. But it must be borne in mind that the concentration of the greater part of the light downwards by the direct

the decorative surfaces to be illuminated, and, as we have seen, is often limited by the necessity of faithfulness to period so often insisted upon.



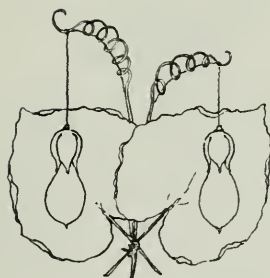
100-light Electrolier shown at the Crystal Palace Exhibition, 1882.



Early semi-indirect fixture.



Semi-indirect bracket lighting with screen to avoid glare.



Bracket lighting with reflecting surfaces accentuating glare.

SOME EARLY ELECTRIC FIXTURES.

TAKEN FROM A TRADE CATALOGUE ISSUED ABOUT 1888.

method, which is rightly insisted upon from a utilitarian standpoint, may not always be desirable from an architectural standpoint; the distribution should vary according to the nature of

The indirect and semi-indirect systems of lighting represent a typically modern development, although, as some of the accompanying illustrations show, they were not unknown in the early history

of electric fixture design. The relative merits of these systems hardly fall within the scope of this paper. It is a question how far they can be combined with any of the traditional styles. Indirect fittings of certain periods (Tudor, for example) are sometimes made, and their effect may be pleasing. Yet an indirect fitting in a Tudor manor house, having, perhaps, half-timbered ceilings, however deftly adapted, would seem to be an anachronism.

On the other hand, in lighting halls with very fine painted ceilings (the Dyers' Hall, recently reproduced in *THE ILLUMINATING ENGINEER*, is a case in point) the method is effective, provided other supplementary lighting is included to relieve any possibly depressing effect from dark surroundings.

A number of typical modern fittings are shown in which indirect and semi-indirect component parts are used, combining the advantages of the three systems in one fixture. These methods are admittedly largely the result of recent improvements in the efficiency of lamps, and are an interesting illustration of the effect of advances in lighting apparatus on the design of the future.

USE OF ARCHITECTURAL FEATURES IN ILLUMINATION.

Finally, a word or two may be said on certain developments in lighting which, while not strictly coming within the scope of fixture design, have a certain bearing on what has been said above. The use of indirect and semi-indirect lighting should have a distinct influence on ceiling decoration, and it is conceivable that such methods might give rise to an entirely new system of decoration. In buildings used mainly by artificial light (theatres, for example) the design of the ceiling has often been expressly adapted to artificial light. Domes have been constructed acting as reflectors, in other cases ceilings and columns of diffusing glass or alabaster have been

built in and lamps mounted behind them, and cornice-lighting has been applied in conjunction with decorative friezes; but these novel methods are not applicable to general practice.

CONCLUSION.

In conclusion, it may be well to summarise the main points of the paper with a view to promoting discussion. It may be suggested:—

1. That in dealing with interiors of a distinctive period the appearance of the fixture is just as important as the illuminating efficiency. In such cases it is best for the architect to select the type of fixture; ensuring, by co-operation with the engineer, that it embodies modern practice as regards efficiency.

2. That in industrial lighting, such as printing offices, factories, &c., these are best arranged by the illuminating engineer, who should be consulted by the architect.

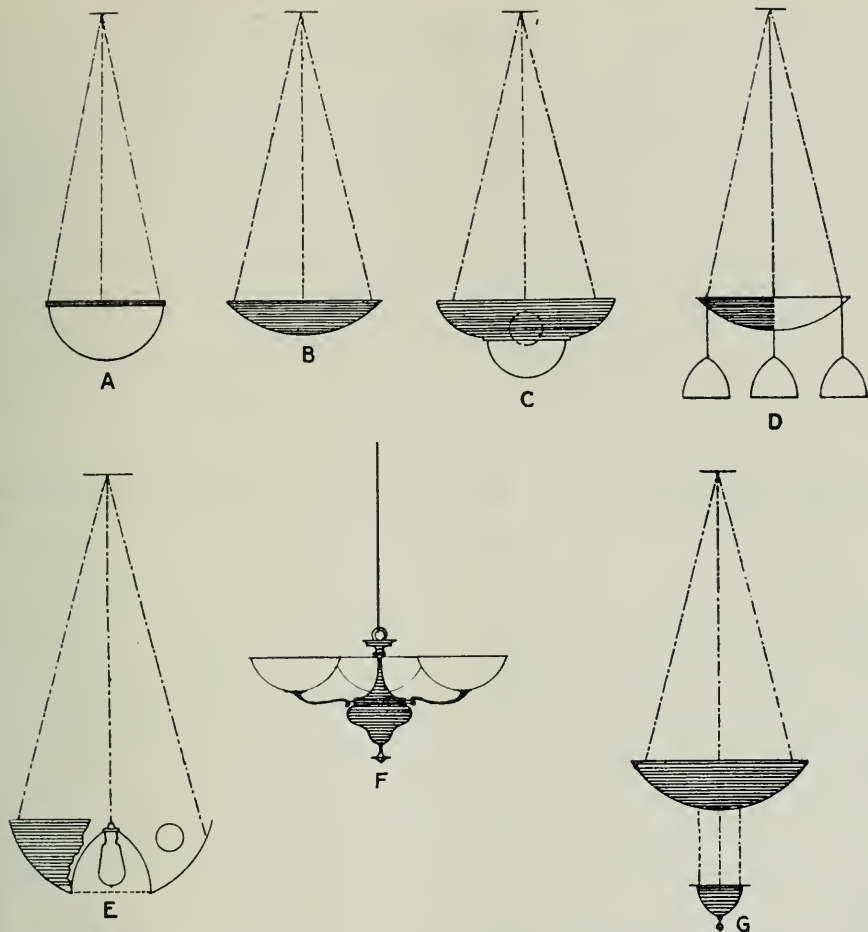
3. That where it is desired to preserve the correct atmosphere of an old-period room it is permissible to reproduce the fixtures of the particular period, re-modelling them carefully to present ideas, which can be done without incongruity.

4. That with a modern room making no claim as to purity in style any system of lighting and type of fixture is permissible as long as adapted to the practical requirements of the room.

5. That in outdoor lighting the decorative possibilities of illumination have not yet been properly appreciated.

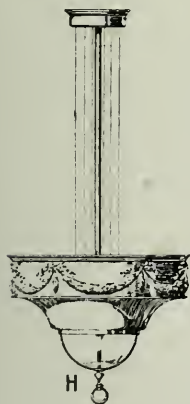
6. That it is sometimes advisable to consider the method of illumination before designing the room, as various systems of lighting are best adapted to enhance certain schemes.

7. That the above considerations point to a much-needed co-operation between the architect, the engineer and fixture designer, with a view to raising the artistic as well as the practical aspect of illumination to a higher plane.



SOME RECENT DEVELOPMENTS IN FIXTURE DESIGNS.

- A.—Ordinary semi-indirect fixture.
- B.—Ordinary indirect fixture.
- C.—Combination of indirect and semi-indirect fixture for half-watt lamp, suitable for large halls.
- D.—Combination of indirect and direct, or semi-indirect and direct fixtures, wired on two switches so that either system can be employed at will.
- E.—Combination indirect and direct, on two switches, so that either system can be employed at will.
- F.—Indirect or semi-indirect fixture, useful where an ornament fixture designed on traditional lines is desirable.
- G.—Indirect fixture, with extra pendant designed to illuminate the ornament and relieve the dark effect of a large indirect bowl.
- H.—Lowering arrangement for indirect or for semi-indirect systems, desirable for ease in cleaning.



DISCUSSION.

The CHAIRMAN (Mr. Frank Bailey) said the paper was a most comprehensive and discursive one upon a very important subject. It contained many points of interest to architects and designers of fittings, and to those who supplied the illuminant or who were responsible for illumination. He thought he could not do better than leave it to the architects and designers to commence the discussion, which he hoped

would be a thorough and critical one, in order to show appreciation of the worthy effort of Mr. Thorpe in preparing the paper. He would now call upon Mr. J. Darch to read a special contribution which he had prepared relating to the subject matter of Mr. Thorpe's paper.

Mr. JOHN DARCH then presented his contribution as follows :—

ON THE PRINCIPLES OF DESIGN IN LIGHTING FIXTURES.

By JOHN DARCH.

FROM the point of view of the fixture manufacturer Mr. Thorpe has given us a very excellent and interesting paper which any architect will fully appreciate, but there are some other points of view in connection with the design of lighting fixtures to which attention should be drawn.

One looks back with pleasure, if not with envy, at the creative minds of the past; but as we are living in a very different age, the question that arises is whether true art does not demand that 20th century light should have 20th century fixtures.

What is true art? Certainly not the slavish copying of the past. That is mere mechanical work. The beautiful art of former days was adapted to its own necessities. When tallow lights of one candle-power were used it was perfectly proper to distribute them on wide-spreading frames brought down nearly to the head level. Some of us have seen the great candle hoops or coronas in old churches or the great branching chandeliers in our old baronial halls, with their tallow cups for catching the grease; and we have seen them, grease-cups and all, not copied but caricatured in modern buildings for use with gas and electricity.

As the Renaissance killed national art so this unfortunate mania for indis-

criminate copying is as inimical to progress as to true art. Before the Renaissance of the 16th century, design in architecture and metal work was evolved out of constructional necessity; art was living and progressive, adapting itself to changing circumstances, and there can be no doubt that if electric light or high-power gas had been then invented, the artists of that day would have grappled with it and produced suitable fixtures.

But we, in our day, are so prejudiced by tradition that we are impeding the progress of our big and promising boy by keeping him dressed in the long clothes of his infancy. Indeed, some people feel that a room without a chandelier is as incomplete as a coat without a tail.

The manufacture of light is daily cheapening and improving, and the tendency everywhere is in the direction of high illumination: we are emulating daylight in its intensity, distribution and colour—and quite right too. How, therefore, can one justify the employment of antique patterns, divorced from their designed purpose to the service of the metal filament lamp or the gas mantle which cannot be reduced to a sufficiently low and congruous intensity? There are, of course, numerous cases where authentic copies of good prototypes or their

modern variations may be eminently suitable, but high-power lights involve an altogether different class of fixtures, or no fixtures at all, and Mr. Thorpe in his later paragraphs admits as much.

In seeking for ideas we may learn much in Mother Nature's school, from whence the greatest artists have ever drawn their best inspirations. This does not mean that we should make brass and iron flowers, leaves or branches, or crawling dragons, stalking storks or flying cupids for gas fixtures. That would be most *unnatural*. If nature made lighting fittings, she would never show her poverty of invention by serving up some of her old vegetable or animal forms, but she would produce something that would be not only original but eminently suitable. And yet—and this is the point—she would make use of the same old principle on which she has made everything else, that of *Fitness*—fitness for its purpose and fitness for its place. In other words, Utility and Beauty conjoined.

In designing, it should be remembered that an essential element of beauty is that the outward characteristics should reveal the inward purpose. Let your designs be true and honest. Necessity is the mother of Design (if one may adapt an old proverb). Make a virtue of necessity and let the necessary features of construction themselves form the lines of beauty.

Utility must be the first consideration, and to that end know what you have to provide for, such as the purposes of the illumination, the intensity required at the working points, the nature of the distribution, the consideration of shadows, the care for people's eyes, &c., and then design your fixture exactly to meet those requirements. After this the soul of the artist enters, under whose governing influence there are few utilitarian forms that cannot be made attractive without piling on a redundancy of construction to make it look like something else. The lines of beauty in a horse or in a human face are entirely made up of essential working parts; nothing has been added for mere ornament. Anything added would be an excrescence, like the wart on Oliver Cromwell's nose. If, however, true art demands it, by all

means let us have the wart or the scrolls or what not; but the whole history of art testifies to the fact that the best work is that in which charm is put into an article without the need of superfluous ornament. The man who can make a teapot graceful and attractive by simply shaping it, has done far better work in the cause of art than he who can only beautify it by masking it with scrolls, leaves and flowers. "Beauty unadorned is adorned the best": and this may be taken as an excellent motto for the design of fixtures.

Leaving general principles, let us particularise and consider, for example, a public hall in which architectural features of the orthodox Renaissance type adorn the walls. The charm of this class of work lies entirely in the proper application of light and shadow, and being designed for a top light, *i.e.* the sky, becomes an abortion when illuminated in any other way. To do our duty to such features we must apply a literal "lamp of truth," and with modern high power light, either gas or electricity, it is easy enough. If direct lighting be preferred, we can light from the ceiling and every part of the hall will be correctly illuminated; the intensity, of course, being made sufficient for requirements below. Now the fixtures for this will hardly come within the ordinary category, but whatever may be necessary should fall in with the design of the ceiling. If indirect lighting be preferred, even a truer effect will be obtainable on the architectural or any plastic features. In both these cases the fixtures should be solid and sufficient, and ample opportunity exists to make the reflecting dishes and their supports graceful in form without extrinsic ornament. If special lighting is required for the platform special fixtures are necessary which should be designed in keeping with the surroundings, affording protection to the eyes of the audience, and the more unobtrusive the better. Suitability is more pleasing than ornamentation and practical success than either, for the mind needs to be satisfied as well as the eye.

Churches, to the fixture designer, may seem to be an easy subject because of the prominence of ecclesiastical art in the past, but in reality it is found to be the most difficult, successful illumination

with them being the exception. The reason is that the fixtures take precedence and govern the illumination instead of the illumination governing the fixtures. In the days when our mediæval patterns were originally devised, evening services were not the rule, and when they did happen, as folks could not read, a few guttering candles met their needs. But here we are, to-day, trying to fit a square peg into a round hole, for the principle of candle lighting will not adapt itself to that of modern illuminants and is, naturally, a disastrous failure. To see anything at all the worshippers in a church have to peer through a forest of low-placed lights on quasi-Gothic standards or pendants or, at least, to endure the glare of lamps from a couple of brass pulpit standards that, however handsome, one cannot admire. The chancel, we are informed, is beautifully decorated, but it is impossible to see it, because of the branched stall standards with their gleaming points of light; and as the upper half of the church is lost in a heavy depressing gloom there is no diffusion.

Much of this is due to the lure of the fixtures; there is more anxiety to get something striking than to provide for the needs of the people. Architects are not always to blame. I have, myself, had much trouble with building committees who are afraid to depart from conventionalities.

The chancel may be easily and beautifully illuminated by concealed lights for which no fixtures, as such, would be necessary. For the body of the church the fixtures would depend upon circumstances, but the days of imposed penances are past, and the people should not be punished by the glare of visible lights. The pulpit or the chancel screen may have handsome standards that could and would be properly admired if the lights thereon were fully screened. Natty little picture lighting fixtures might be designed for the wall notices.

In public and private Picture Galleries, chandeliers or pendant clusters are commonly used, consequently the pictures cannot be seen without considerable dodging. Where there is an extensive ceiling, indirect lighting gives the best results and opportunity is afforded for a handsome fixture. Where there are sky-

lights the artificial lighting should be direct and come from the same angle as the daylight. Short pendants, hooded with opaque reflectors, are economic and give good results; and here is an open field for the designer, for what little has been done in this way has made no pretence to beauty.

In Domestic lighting, it may be argued that the orthodox fixture is a *sine qua non*. Let us take the drawing-room. If the householder is artistic there will be something to be seen. Now the ordinary fixture, with the lamps dotted about near the eye level, militates against a proper view of anything. The lighting in a drawing-room should be general and the lights kept out of the eyes. For direct lighting, ceilings may be designed and panelled out to take holders, in which case nothing in the way of fixtures is necessary. In indirect lighting there is ample scope for artistic fixtures. In small drawing-rooms brackets of some



FIG. 1.

“period” would be admissible if the light were screened so as just to avoid the eyes and yet admit direct light to the whole of the ceiling and walls. The most unreasonable and yet the most popular form of brackets and chandeliers are those with swan-neck arms (Fig. 1) which look downwards and outwards, and carries a “shade” that shades nothing.

In a dining-room the principal consideration is the table, and in most cases nothing is better than a pendant with a large and densely-coloured flounced shade adjusted to a width that will just avoid the eye in sitting or standing. Here is an opportunity for taste rather than elaboration. Such a fitting should be adjustable at least up and down, and better laterally also. The derrick-looking “Surprise” pendant is exceedingly useful in this way for rooms of a moderate size; its great advantages amply compensate

for its want of symmetry. In larger rooms, the more shapely rise and fall table pendants are preferable, while simple but elegant standards and brackets, which may aspire to a "period," may be necessary for table ends, sideboards, fireside, &c.

In libraries, whether public or private, wide-spreading foliated brackets and chandeliers are particularly out of place. In the small library a neat central light will serve both for general illumination and for illuminating the bookcases. The designer's ingenuity will be well expended in producing a good table lamp. It should be elegant, solid and simple: it should overhang and be provided with a device that would make it easily adjustable so as to vary the desk illumination from 2 to 10 foot-candles.

When Art ceases to be consistent it ceases to be true. There is a tendency with certain so-called artistic electricians to mistake oddities for art. For example, a Birmingham edition of a Roman *hand* oil lamp, as Fig. 3, has been slung up as a pendant and an electric lamp bulb stuck in the spout—not as a joke but for serious use. Again, a glass vase instead of standing on its base (Fig. 4) has been chained up as a pendant and used as a globe with a lamp inside.

Finally, it may be pointed out that a serious impediment to progress exists in the great fixtures industry itself. Thousands of workmen are daily engaged in the monotonous production of stock patterns over which the controlling force is not art but dividends. Mr. E. L. Elliot,



FIG. 2.

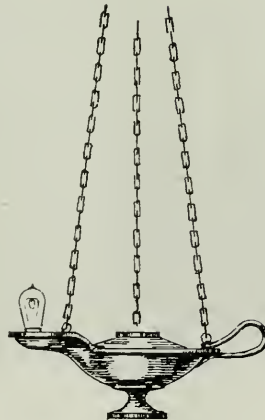


FIG. 3.

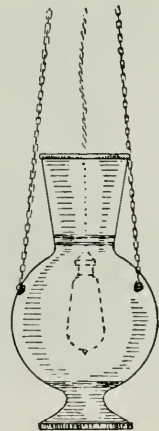


FIG. 4.

Badly-lit porches, halls and staircases are the rule—largely attributable to misplaced lights but sometimes to absurd fixtures. For example, there is the clumsy Guy Fawkes lantern (Fig. 2)—the acme of high art—that throws more shadow than light and enables us to discover the presence of mats and occasional steps in a manner more lively than pleasant.

of New York, in a paper before the Illuminating Engineering Society said: "There is no denying the fact that a very considerable part of the faults of lighting are directly traceable to a desire for profit on the fixtures. Look," he says, "at any fixture you please and judge for yourself how much is mere exerescence hanging on in the name of art, but having its true motive in the pocket-book."

Mr. A. P. TROTTER said the title of the paper was a reminder of the disadvantage in modern lamps whether gas or electric, as it contained the word "fixture." When he was young, lamps were not as a rule fixtures. When the daylight failed they used to ring for the lights and the butler would come with the colza oil lamps wound up and he would adjust the drip, but one did not live with the lamps. It was something of a disadvantage that we had to do so nowadays, and their appearance became of very great importance.

take place. We should have supply first, and, judging from what was offered us, we should demand what we liked.

The art of this country fell to its very lowest ebb soon after the exhibition of 1851, and twenty or thirty years later William Morris began to produce things which were so beautiful that they created a demand. It was impossible to lay down laws about these things. It must eventually be a matter of opinion, and the important thing was that public opinion should be instructed and guided to the right lines. The dogma that superfluous



Drawing-room illuminated by Louis XIV. candle-brackets. (Mr. A. P. Trotter.)

Here came in the question of art. To many artists and architects and people whose business it was to produce beautiful things this was an appropriate and natural subject to discuss, but illuminating and other engineers had to try to learn in humility what they could on this important subject. He said "learn," but art could not be taught; it could only be hoped for. In many subjects there were the laws of supply and demand, and as the demand arose so the supply was provided. In artistic matters, however, it seemed that the reverse should

ornament should be removed was one which he could not accept. He would be very sorry to have everything denuded of superfluous ornament.

Coming to practical matters, there were, of course, very different requirements for different purposes. The old ball-rooms of our forefathers were lighted with magnificent chandeliers containing wax candles, and these were fitted as part of the design of the room. In our domestic life the lights we used when we received friends were obviously different from those which were used for every-

day purposes. On these occasions more light was required, but even here it was a matter of opinion. He had said on a good many occasions, and he repeated it, that for reading nothing was better than a shaded lamp, but Dr. Louis Bell, of America, and others held that this was entirely wrong. Indeed, Dr. Louis Bell had caricatured this question of shaded lamps. Every man, however, must judge for himself, and we could not lay down any laws or dogmas. When we came to the "style" of these things we were met with all sorts of difficulties.

The shopkeeper tried to teach us to go in for "period" furnishing. It might amuse some people to collect furniture for different rooms for different "periods" but many of us would be quite content with mixing the "periods" as long as the things were in themselves good. Electric lighting, of course, lent itself to adaptation of existing lamps in a most remarkable way.

In conclusion Mr. Trotter showed a photograph of a corner of his own drawing-room which, he said, Mr. Dow had very kindly taken for him the previous week. The room, he added, showed a mixture of styles for which he was not inclined to apologise.

Instead of the usual white imitation candles he used brass tubes coloured to match the old metal. The shades were opal glass ground on one side, and were larger than is usual with candle lamps. The object was to avoid glare by arranging that the brilliance of the shades was little, if any, greater than that of the white walls. He had some difficulty in securing this. The lamps themselves could not be seen from any part of the room. As a matter of fact, the lamps gave just about double the light that he desired, as he had the misfortune to be supplied at 200 volts continuous current. The lamps had to be connected three in series.

Mr. E. P. WARREN: At this time of external gloom and of the eclipse, temporary we may hope, of civic illumination, it is cheering to think and talk about internal lighting.

Mr. Thorpe has dealt largely with successive architectural periods, and seems to suggest—I hope to avoid and mean to avoid doing him any injustice—that

architectural style, as we now call it, was—even in the earliest periods of its manifestation—self-conscious, and that coeval contrivances for artificial lighting were consciously kept in architectural subordination to the building fashion of the period. This was never the case, at any rate, in the early periods of development. Early Egyptian, Greek, Roman, Byzantine, Romanesque, or the successive mediæval phases, when there was no abeyance to prescribed fashion, to a revived or adoptive manner. The lighting contrivances (and I cannot accept the American-sounding and highly modern term of "fixtures" for the hundred unfixed lamps that were used for every one that was actually fixed) were evolved from sheer practical needs, tempered by the craftsman's artistry, and rendered comely and pleasant by the perfection of sheer fitness of form, and the ornamental fancies of the worker—always, of course, influenced like his brethren the contemporary masons, carvers, glaziers, potters and painters by the traditions of his craft.

The candlesticks, sconces, lamps and lanterns were as much the outcome of the conditions of their time, and the habits of their users, as the contemporary cups and platters, knives and spoons, spears, swords, ploughshares, boxes and barrels. They were not designed consciously in a style, and they have "style" because they have fitness and character.

Fitness and character—those are the qualities which in all matters of applied design we must strive for, if our workmanship in architecture—in the greatest as in the least of its adjuncts—is to be of any value or interest.

The abeyance to archæology, to archaic style in modern work is the great and constant danger. A man may be strong enough to override it, and to express himself with force and individuality in an adopted manner, as a man may express his ideas in an acquired foreign tongue, as Christopher Wren did, but such men are rare. The designer must think what a thing is "for" first of all, and with such things as appliances for electric lighting he should first and last consider form appropriate to the purpose in hand, then if he is designing for special positions in a special building he has not to

consider its nominal architectural "style," but its actual character and effect. If he is designing, as he generally is, "in the air," so to speak, he has to consider, after achieving fitness to practical purpose, a general adaptability to the shape and requirements of average positions in modern buildings.

If such designers can give simple, strong and graceful form, pleasant contrasts of surfaces, of curves and angles, to a thoroughly well-made piece of practical workmanship thoroughly adapted to the effective support and use of electric lamps, he need not have much fear of its looking ill in any sort of building.

There is nothing more pleasing than the contrast of manner arising from different periods of workmanship and different authorship of the various fittings naively added to old buildings.

Take as instances the splendid 17th-century "Spider" candelabra of churches, English and foreign, or the beautiful crystal chandeliers (18th century) in the Gothic parish churches of France.

Compare them with the self-conscious and expensive "Gothic" imbecilities of the 19th and 20th centuries designed "to fit in with the architecture," and hopelessly failing to fit in with anything whatsoever.

Let us be done with the perpetual confession of ineptitude, the laziness of always cribbing dead men's ideas and shrinking from thinking for ourselves, and in dealing with a new method of illumination let us, for goodness' sake, deal with it honestly.

It is dealt with quite honestly in many places where mere decent practicality is sought, and with results that satisfy any artist. The plain brass lanterns on ship-board and in corridor carriages are pleasing in design from their plainness, fitness and excellence. There is nothing offensive in the plain pendants used in unimportant bedrooms, and broadcast in offices, schools and hospitals.

There is, of course, no need always to be plain, but there is need to be sane. In copying old examples for modern use there are many dangers. The old lamps, lanterns and candle-holders of various sorts were made for the burning of oil, liquid in a lamp, congealed in a candle.

The forms naturally evolved from these uses cannot be appropriate to electric light, which needs no receivers, no grease cups or retainers, but does need ducts for wires and sockets for lamps. That is one danger in design. Another and more serious is that, without very careful discrimination and scholarly knowledge, fearful mistakes as to the use of ornament may easily be made. I noticed in one of the lantern illustrations a four-light pendant "evolved" by copying the form of a Greco-Roman hand-lamp, probably a Tomb lamp of the early Christian era, and retaining in the copy a pierced circular disc containing the initials X. P., which are the Greek letters Chi, Ro, the initials of Christos, or Christ. A lamp bearing those initials might be appropriate in a sanctuary, but the suggestion appeared to be that this modern "evolution" could be sold for general secular use. Can you think a lamp bearing repetitions of these sacred initials appropriate to a drawing-room, a hotel lounge, or a club smoking-room?

Architects like myself are driven to using revivals and imitations, sham candles and the rest, because designers of fittings won't use their undoubted talents and skill to give us fine simple masculine form thoroughly suitable for electric light and at the same time handsome bits of handicraft, at the price or near them, for which we can buy the well-made imitations. In saying this I am not inveighing against designers of electrical fittings. The designer is not more to blame than most architects or anybody else, and architects, amongst whom I number myself, are perhaps the chief sinners. They are always harking back and copying. It is very necessary that the architect or the designer should carefully study the best things in order to find out and understand their real merits, the excellence of their workmanship and the charm of their materials; and probably it is better that they should at first copy a little, because they might come to grief if they did not; but the sole object should be to design a form which is appropriate to its use. Where it is a question of the evolution of new fittings for electric light there is a splendid chance, because this is an illuminant which is extraordinarily easily

used in some ways. Mechanically it is easy to introduce the wires; but, in one respect, electricity has resulted in the evolution of a most disastrous form of fixture, viz., the standard lamp. The wires necessary for connecting them are always getting into the way and causing trouble, and I really hope that something better than this will be evolved in order to avoid the unpleasant flexible wire.

In regard to the lighting of pictures, the ultra-modern system of lighting fine pictures by a long foot-light attached to the frame is a very bad one artistically. It is uncomfortable, because there is frequently far too much light on the surfaces of the pictures, which spoils the general effect of the room. Moreover, this light is practically useless to the pictures. I agree with Mr. Trotter that the lighting of ordinary rooms is largely a matter of individual taste. In a dining-room one man will want all the light concentrated on the table and the rest of the room in semi-darkness, whilst in a drawing-room one lady likes to have all the corners dark whilst another desires plenty of light in every corner. Artistically the happy medium is between the two extremes. In a room like a drawing-room there should be central illumination, or at any rate an illumination of a pervasive kind, as a stand-by which will really light the whole room, because light has a very curious effect upon people. If one goes early to a party and the room is badly lighted there is an excessively depressing and silencing effect, whereas if the room is brilliantly lighted this perks people up and they begin to talk cheerfully at once. With regard to public buildings or colleges and the like, the problem is an entirely different one. In a college dining hall of the type of those of the Oxford and Cambridge Colleges, there are generally roofs or ceilings of some individual character and, beneath them, pictures. The necessity here is to secure a pleasantly diffused light while preventing glare. I have tried various expedients, and prefer a certain number of pendants and a certain number of wall brackets. At one college in Cambridge I made a good many experiments and put up experimental fittings which I can only describe as a fishing rod with a lantern

at the end. We had tried many other fittings from well-known makers, but decided at last to retain the fishing rods, as they seemed to give a better result than anything else. I put in a plea for common sense and for crediting architects with common sense. Architects are very often regarded as mere arbiters of style. An architect if he is going to do anything worthy of being considered serious architecture must design his building, from all points of view, for the purpose for which it is intended and is to be used. Therefore one of the things to do is to consider the building, while it is in plan, from the point of view of artificial illumination as well as daylight illumination. In this way one will be able to save a good deal of one's client's money, and a certain economy is effected, by predetermining the positions of the lights. For instance, it is possible to light two passages joining one another at a right angle with one light, if the matter is taken in hand properly, whereas on the other hand it is equally possible to arrange the one light so that only one passage is lighted. That is a very humble illustration of what I mean. With regard to the positions of lights generally, one of the most abominable arrangements is that which is apparently adopted in all British hotel bedrooms. There is a light over the dressing-table and another in the middle of the room, and why British hotel-keepers should adopt this system, which Continental hotel-keepers avoid, I do not know. The result is that if one wants to read in bed the pillow has to be put at the foot of the bed or else one has to read with the light right in the eyes; and when it is desired to put the light out it is necessary to cool one's feet in order to go to the door, where the switch is usually placed. This is a little point in comfort which, without one penny added to the expense, goes a long way to increase the comfort of the human species.

In conclusion, I have to thank Mr. Thorpe for his paper, and you, Mr. Chairman and gentlemen, for your kind invitation and your patience to-night.

Mr. J. S. Dow (Hon. Assist. Secretary) then presented a communication to the discussion from Mr. W. D. Helps (see p. 137).

Mr. Dow then proceeded to show a series of slides illustrating some American and Japanese fixtures. The first three illustrations were of unusual lamp-posts recently shown in the *Edison Monthly*. They did at least represent an attempt to design posts to suit the surroundings.

The other illustrations (Figs. 4-9 illustrating Japanese fixtures) were sent to Mr. L. Gaster some time ago by Mr. Ohya of Japan. The first two pictures showed some Japanese silk lanterns designed for use at the Imperial funeral of the late Emperor of Japan.

There was just as much need for scientific investigation with regard to gas fittings as with electric light; indeed, possibly more so, because although at present electric light fittings could be obtained of a fairly good design, gas fittings were at present often only to be obtained from an ironmonger's stock and offered a far greater scope for improvement in design.

With regard to the vexed question of whether we should copy or not, it would be obvious from the illustrations shown that evening how true artists, such as



FIG. 1.

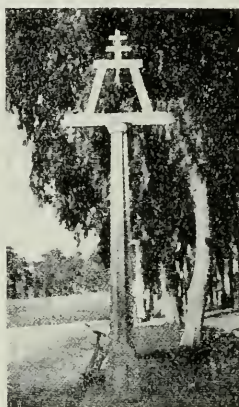


FIG. 2.



FIG. 3.

FIG. 1.—Design to harmonise with "Old English" mansions in the vicinity. (Los Angeles.)

FIG. 2.—An interesting design drawn from the belfry of an old Spanish mission near by.

FIG. 3.—Standard in park made of greenish bronze to imitate colour of adjacent palms, &c.

The remaining figures are reproduced from a Japanese catalogue and are interesting as showing how that country is adapting its characteristic decorative methods to electrical fixtures. Some of the Japanese designs are very pleasing, the use of decorated silk for lanterns being very effective. The prevailing tendency in Eastern lighting is towards softness and mellow light, and it is to be hoped that these artistic effects will not be vitiated by the abrupt transition to the brighter illuminants of the present day.

Mr. P. J. WALDRAM warned the Society against the danger of drifting into the view that electric light is the only field for ingenuity in the design of fittings.

the Japanese were, even if they began by copying, finished up by adapting the best of what they copied, and produced beautiful forms. He was quite sure that everybody must have been struck by one or two exceptionally fine pieces of simple and beautiful design in the Japanese examples which were obviously not copies but adaptations. In connection with that he would like to draw attention to a remarkably simple and effective type of electric light fitting for a church. That was at St. Jude's, Golder's Green, and was simply a large copper ring spreading a bunch of flexible wires, and at the end of each wire was a plain bulb lamp, without any attempt at shading. From the scientific point

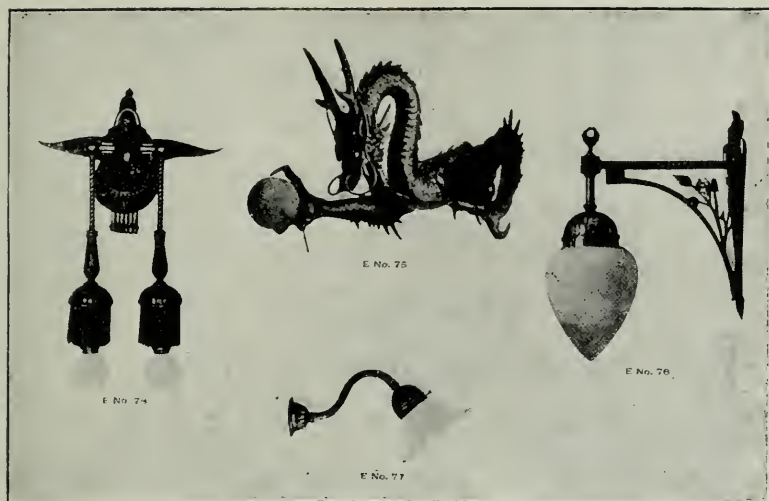
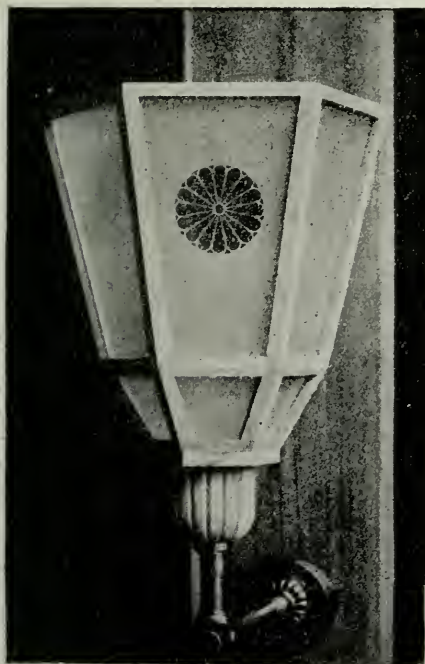


FIG. 5.— Note the interesting dragon design in centre.



FIGS. 6 and 7. — Japanese silk lanterns designed for use with electric light at the Imperial funeral of the late Emperor of Japan.

of view that should be too terrible for words on account of the glare, but as a matter of fact the position of these lamps had been so carefully considered and placed at such a height above the eye that lamps near the observer did not fall within the ordinary line of vision. Personally he had found the effect excellent, and, as far as the artistic side was concerned, nothing could be more pleasing, although it was absolute utility and nothing else.

blame the fittings manufacturer for having slavishly copied existing types and thus worked upon hard and fast lines. It was, however, no use the fittings manufacturer designing new forms and new types. He did not think he was called upon to do so, for if he designed fittings to his own ideas he doubted whether they would be accepted by the architects as forms which they could embody in their decorative schemes. Whilst he did not believe that architects

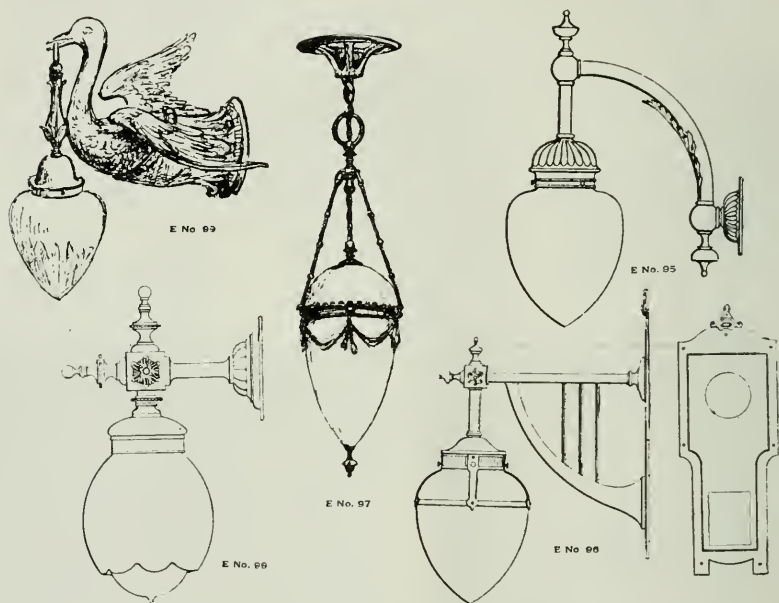


FIG. 4. A page from a Japanese catalogue.

With regard to Mr. Thorpe's conclusion, that conditions in public buildings reflected the artistic sense of the nation, "thank goodness," said Mr. Waldram, "they do not." But those who designed the conditions in public buildings were responsible to the nation, whereas the designers of private buildings were responsible only to their individual clients.

Mr. C. H. BURT, speaking as a fittings manufacturer, who obtained his livelihood in conjunction with, or rather under the guidance of, the architect and the consulting engineer, remarked that most of the speakers had been inclined to

would admit that they were themselves hidebound by tradition, nevertheless the successful architects were those who employed the classical details of bygone ages. It was fairly well known to those who had been speaking that the electrical fittings manufacturer must follow the work of the architects and designers of decoration. Unless the fittings manufacturer to-day could describe his fittings as belonging to certain accepted classical styles, he did not think he would continue to conduct a successful business.

A celebrated architect, Sir John Burnett, once said to him, "Mr. Burt, how do you account for it that with all

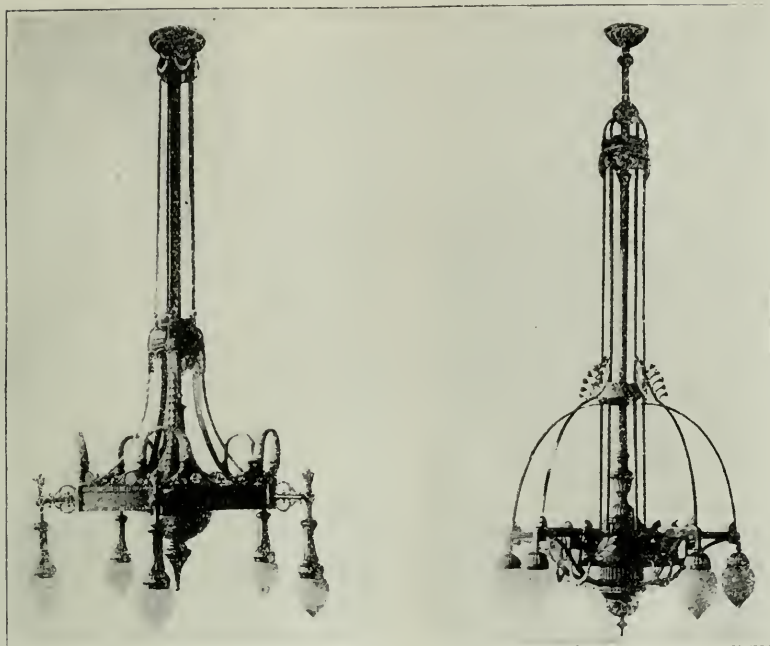


FIG. 8.—Adaptation of conventional electric fittings to Japanese design.

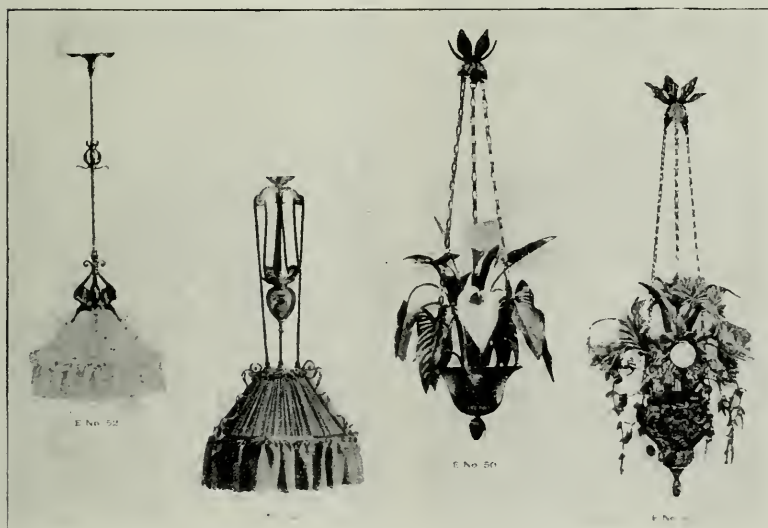


FIG. 9.—Note the use of imitated flowers and foliage on the right and the reproduction of ordinary Western designs on the left.

our modern architects and modern designers none of us have succeeded in evolving a form which is so graceful and acceptable to the discriminating client as the candelabra of the past and the electrical candle fitting?" This was a question to which at the time he was unable to offer a satisfactory reply, but he had come to the conclusion that the form of the candle being a simple vertical column is the one which best conforms to the law of uniformity or symmetry, and it is an accepted fact that the artistic effect of all symmetrical objects is improved by repetition and grouping, as for example, rows of architectural columns, avenues and groups of trees, lines of soldiers, pairs and sets of vases, rows of statues, panelled walls, etc., etc.

It was doubtless for this reason that the grouping of candles was 35 centuries ago discovered to be the most agreeable manner of multiplying a series of points of illumination of uniform intensity.

This is the most remarkable fact in relation to lighting fittings, as the record of the manufacture of candelabra dates back to B.C. 1491, when Moses was commanded to make a candelabrum for the ark upon certain specified lines, and this form of candlestick is still in use in every Jewish synagogue to this day (see Exodus, xxxvii. 17).

There was another successful form of electric lighting fitting which had come into vogue during the last year or two, and that was the dish fitting, the dish being composed either of a number of different materials which Mr. Thorp had already described as opaque, semi-opaque and in some cases transparent and of cut glass. He would ask the architectural members of the Society to bear in mind that the manufacture of decorative fixtures and fittings is handicapped by the practice of electrical engineers which had to be conformed to, namely, that the pressure or voltage at which the current was supplied for domestic use is not that which the fittings manufacturer would choose as the easiest for him to conform to. The introduction of metal filament lamps had very seriously added to his difficulties, because the voltage in vogue at the present moment was far too high for decorative purposes. The present

day high-power metal filament lamps were too bright for decorative lighting, and efforts were now being made to provide some means for screening this brilliancy—in other words, to secure efficient diffusion. Many of the incongruous-looking fittings of to-day were either made for or were adaptations of fixtures which had been made for electric lighting under conditions which were not the conditions of to-day. When London was first lighted by electricity the voltage was 50. Then it was increased to 100 volts for the economy of the supply station; it was afterwards doubled to 200 volts; whilst the common practice to-day was 240—250 volts. The metal filament lamps on the top of that had more than doubled the length of filament which had to be accommodated in the bulbs and fittings, and by public demand the volume of illumination was on the average doubled or perhaps four times that which the fittings maker formerly had to provide for.

The various forms of electrical fittings which were now in most demand were those supposed, but not very correctly, to have been designed by the designers of furniture of the 17th and 18th centuries. There had been thrown on the screen illustrations of what had been called Chippendale lighting fixtures. That was a broad description, but in reality the so-called Chippendale fixtures were probably never designed by Chippendale. He was a manufacturer of chairs, principally, and a designer of decorative furniture, and he probably never designed a lighting fixture in his life. What was actually at the present time known as Chippendale furniture was designed by not less than seven different designers, and their names were to be found in most of the reference books. Then there were the so-called Adam style of fixtures, which were made at the time of the architecture of the Bros. R. and J. Adam. There were, however, many contemporary designers whose work was probably called "Adam style," but it was nothing of the sort. It was merely contemporary work and represented the current fashion of the day. If there were faults in the fashion of the time, or if the Adam style was pure or merely a resurrection of the classical designs and details of past ages

or otherwise, it was the result of the accepted taste of the time.

That must explain why the electric fixture manufacturers at the present moment were copying or reproducing or devising new fixtures in the decorative styles of the 16th, 17th and 18th centuries, and it is not their fault, if fault there be, that the public demand lies in that direction. The manufacturer has to conform to the demands of his market. It must also be borne in mind that the scope for new and original design in decoration grows constantly narrower with the age of the world, and it was to his mind doubtful whether future design would undergo any remarkable change from what is accepted as the classical form and ornament of the past.

Mr. J. G. CLARK showed some slides illustrating fixtures of a special character.

One slide (p. 134) illustrated the fixtures used in a French church in Soho. They were, he believed, the fixtures originally installed in the church and were retained when the lighting was modernised by the use of incandescent gas.

Another slide illustrated the simple fixture used for the support of incandescent gas burners at St. Mary's Church, Stoke Newington, a copy, he believed, of Salisbury Cathedral. Several slides were shown illustrating the lighting in the body of the church and in the choir, taken in both artificial and natural light, and it was interesting to study the appearance of the architecture in each case. An important point mentioned and



St. Mary's Church, Stoke Newington.
Incandescent gas illumination.



St. Mary's Church, Stoke Newington.
Daylight illumination.



Choir, St. Mary's Church, Stoke Newington.
Incandescent gas illumination.



Choir, St. Mary's Church, Stoke Newington.
Daylight illumination.

**VIEWS OF ST. MARY'S CHURCH, STOKE NEWINGTON, BY INCANDESCENT
GASLIGHT AND BY DAYLIGHT. (Mr. J. G. Clark.)**

illustrated was the great value in church-lighting of light rays distributed above the horizontal plane from a relatively low position. With heavily-shaded units giving a preponderance of downward light, the beauties of church architecture are cast in gloom.



French Protestant Church, Soho Square.

I would like to take this opportunity of expressing my appreciation of Mr. Thorpe's paper. For those of us who have not given close attention to the æsthetic side of the question in its relation to pure architecture the paper will prove an extremely valuable work of reference.

MR. PERCY L. MARKS: I should like to congratulate Mr. Thorpe on his interesting paper and to emphasise the desirability of co-operation between the architect and those engaged in the various specialised classes of work which together constitute "the perfect building."

The architect, who thinks he knows everything as well as, or better than, the individual scientific experts, is a snare to himself and a delusion to his client. Every architect should have a mastery over the plans and elevational design, and should have a competent knowledge of constructional detail, and should likewise have an intelligent appreciation of the sciences of lighting, heating, ventilation, and acoustics. If I do not include in the latter list sanitary science, it is because of the overpowering necessity existing that architects should specialise in this branch as in construction. The fact is,

that the old name of "Master of the Works" more adequately conveys what should be the position of the one referred to, than does the term "architect."

As regards lighting, this must, I think, be regarded as an empirical science to a large extent, both in regard to artificial and natural varieties. It may be deemed to be at once subjective and objective, variable though limitative. The amount of natural light provided in any room through definite openings will not only vary according to the time of day, but also will be dependent upon the wall-coverings, the furniture, and other factors; we know how much lighter, for example, a room appears with the walls stripped to the plaster under the hands of the decorator, than it does under normal conditions; the draperies, too, are a potent influence. Therefore it is difficult to lay down any hard and fast rules.

But when we consider artificial lighting, we come into a region where I will confidently say that no architect ever devotes scientific research as to quality and quantity; he includes a "provisional sum" in the contract for "lighting fittings to be used or deducted in whole or in part, as the architect shall direct"; he specifies so many "points" in each room and corridor—and then, consults a catalogue; that this method has lasted so long speaks eloquently for the sheep-like nature of the public. Personally, I think that the closer the approximation of artificial illumination to the appearance of natural lighting, the better; and finally I have no hesitation in saying that for all buildings, except where the most rigid economy is required, the co-operation of various experts should be invited, and I am indeed inclined to believe that this would actually prove more economical in the long run.

MR. A. E. PENN endorsed the previous speaker's desire for co-operation between the three individuals mainly responsible for a building. The difficulty at the present moment was to get professional gentlemen to take into consideration that we are now undoubtedly living in the age of specialisation, and that it is not possible for us to be all perfect in so many phases of such an intricate subject. Illuminating engineering has now become

a science in itself, if it never was before, and the time had come when all should freely co-operate with one another and give the advantage of each other's specialisation for the benefit of the common object in view. That seemed to be the aim of the author in his paper, and if it could be achieved he thought we are undoubtedly in for much better times than had been experienced in the past.

The CHAIRMAN (Mr. Frank Bailey):—The demand for a high standard of illumination and the use of lamps of high candlepower, or at any rate of a higher candlepower than was formerly used before the introduction of modern illuminants, and the certainty that the tendency will be to use lamps of from 100 to 1000 c.p. at no distant date, compels us to revise our notions regarding the type of fitting or fixture we are accustomed to associate with the use of artificial lighting. We should remember that the fitting is not necessary for the lamp; the lamp can be complete in itself, and it can be placed anywhere—suspended from a cord or fixed to the ceiling. The purpose of a decorative fitting is therefore more difficult to define as being absolutely necessary for the particular work to be carried out, and there is a danger that by adhering to the old notions of what is appropriate we may reach the stage when the fitting requires to be illuminated, and the room to be lighted becomes of secondary importance. The revolt against so-called artistic fittings is shown by the craze for cornice-concealed lighting, and also to some extent by the various methods of securing indirect lighting; although in many instances of this kind we see examples of the need for illuminating the fitting itself, as the author of the paper has shown us a lantern slide illustrating the benefits of illuminating the under surface of a bowl used for indirect lighting. If these methods are carried out to a logical extreme there is no reason why such fittings could not also serve a double purpose and be used for plants and flowers during the daytime. We must admit that many of the old designs, standardised by their excellence and hallowed by the traditions of ages, were more suitable for the particular

illuminants then available than for the requirements of the present day. We cannot always live with the wax candle, or the imitations of it which degrade modern lighting. We have grown to require more light, and find that we can get it without inconvenience of dirt or smell, or vitiation of atmosphere, and at a trivial cost. We must therefore either do without any fittings or conceive something which will carry a lamp of little or no weight, and do this without any appearance of triviality. If, on the other hand, we can consider the amount of light as equivalent to weight, then the artist can get to work on a substantial design of some solidity.

The Author of the paper has mentioned the desire of the architect to admit plenty of daylight by providing ample window capacity, and it may appear desirable to utilise this wisdom by placing lamps outside the windows and thus obtain direct outside lighting. With a desire to secure some economy I have attempted this method of lighting an interior, and I hoped to light an approach to my house simultaneously with giving a light from outside into rooms and staircase, &c., but the effect is not pleasing and seems unreal, although it has one advantage that the windows are kept reasonably clean; but it also has a distinct disadvantage, as during war time the police object to its continuance. Perhaps a better plan would be to arrange inside lighting for outside use in cases where there was anything worth looking at, such as the stained-glass windows of Westminster Abbey and other places.

The Author, in mentioning design of lamp-posts for street lighting, does not point out the necessity for securing a high elevation. Artistic embellishment of such structures becomes a hazardous operation, for experience has shown us that dangerous projections, necessary apparently to secure artistic effect, have an awkward habit of hitting one on the shoulder or perhaps knocking one's hat off. The finest example of a lamp-post in London can be seen in Trafalgar Square, where the Nelson Column is simply wasted, and a statue we all want to see is placed far out of the reach of normal vision. This could easily be altered by

placing lamps at the top and putting Nelson on a pedestal below.

Mr. F. T. CASH (*communicated*):—Mr. Thorpe's admirable paper read on the evening of the 16th inst. is of a very illuminating character. Had illness not prevented me I should have been delighted to add my personal expressions to his upon such a vitally important matter.

The art of designing is inherent in the human race, and would appear to be a prior expression of artistic activity to that merely imitative art which later grew to such preponderance that the art of the designer, and eventually the designer himself, became almost submerged under the vast mass of pictorial effort. Such effort in the course of time has attained a greatly exaggerated value, but your Society would not appear to be of a nature to which one should deliver an address on the genesis and organic attributes of design; hence I confine the following remarks to that aspect most closely in touch with the aims of the Illuminating Engineering Society.

In considering domestic or public lighting the designer of fixtures should bear in mind two great cardinal principles, to wit, contour and picturesqueness. The most perfect design is one that does not obtrude itself on the mind, which can only receive its impressions through the eye. It should sink into just proportions with its surroundings; weight, size, colour and detail should never detach the fitting from the scheme. Its detail, should one desire to examine more closely, should be such in weight and balance that it can be appreciated instantly. More detail than may be comprehended in a cursory glance must appear out of place in the scale of a fixture suspended well above the eye level, hence the insistence upon contour and picturesqueness, which values should equally satisfy alike the connoisseur and the uninformed. To illustrate my meaning I would draw your attention to that class of candelabra of the Dutch and Flemish School, together with its English development on similar lines. In such candelabra the principles to which I refer have full illustration. The multiplication of the simple sweeping arm gives a contour which is immediately picked up by the eye. No matter how multitudinous the

arms making up the number of lights, the scheme is graspable. Should one desire a closer inspection the several parts that constitute the whole are found to be agreeable in themselves. The massive baluster body of varying outline holds the light and shade, and by reflection of the arms in itself creates its own richness and wealth of detail. The nearer any design in any style approaches these two principles the more satisfying and successful is the result.

I wish next to draw your attention to the wonderful creations of the designer covered by the periods Louis XIII., XIV., and XV. In lighting fixtures, as well as other decorative articles of domestic utility, each period represents the embodiment of cardinal principles with local differences of expression. I particularly draw attention to these periods, because so far as I can perceive they are the last expressions of simplicity, breadth, and strength. To me nothing is finer than the noble scale of the best work of the Louis XIV. period. Breadth of detail, strength of line, bold contour, and strong execution result in a perfect "tout ensemble." The later designers deserted these broad and pleasant ways, and became more and more addicted to using a wealth of fine detail with marvellous execution, the resulting product gaining in fineness but losing its true scale value. To some considerable extent the lost feeling was recovered by our designers working in the Queen Anne and earlier Georgian periods, after which the later Georgian and then Victorian deluge with its utter abominations saw the light of day. Not the least distressing feature of this desolation was the supplanting of the artist creator and artist patron by the modern commercial system with all its attendant horrors.

Lest the immediate foregoing remarks should be misunderstood, I imply by them the loss of that genuine spirit which animated our further forbears and the substitution of an uncaring, uninformed, purchasing public; and until we come to understand the height, depth, and breadth of all that is implied by the word "education," the world of design will still be governed by the stridently powerful, uneducated, and I fear me uneducable Philistine.

Mr. W. D. HELPS (*communicated*):—It is an indisputable fact that the method of producing light from gas has to a certain extent influenced the design of fittings. The flat-flame burner, the first type used—and the nearest approach to burning the gas at the end of an open pipe, as was done when gas was first discovered—was, and is, in itself such an insignificant contrivance that it always looks out of balance with the best proportioned fittings. The upright Argand Burner which followed was a trifle more imposing in appearance, but it did not lend itself to a particularly artistic arrangement owing to the length of glass chimney essential for its good working. Next we had the regenerative lamp, which, in some of its types where Doulton Ware body was used, was more or less ornate and somewhat heavy.

The introduction of the upright Incandescent Burner did very little to improve the fittings on which it was used, and we had to wait for the Inverted Incandescent Burner before any marked improvement in the design of gas fittings was possible. This inverted burner lends itself to lines and schemes that were impossible with the upright types, and owing to the fact that it could be made of very small dimensions it will harmonise with fittings of much lighter construction. The fact that gas was first burned at the end of an open pipe is probably the best indication of the causes of the slow progress made during, say, some 80 years during which gas was used. The bulk of the fittings made during that period were simply adaptations of the original method of burning gas, very little initiative or ingenuity being displayed in designs.

Probably the introduction of electric light had far more to do with the improvement in the design of gas fittings than any other single factor. The electric lamps could be used in any position; they were wind-proof, did not give off any great amount of heat, and the wires necessary for carrying the current were of the smallest dimensions. In the gas fitting the bulk of the metal work was looked upon as necessary for conveying the gas to the burners or for supporting shades or globes. With electric lighting the metal work was considered more by way of ornament than of serving any useful

purpose, and it is quite natural that with the introduction of these lightly constructed electrical fittings, the designers of gas fittings should in turn set about to see in what way they could reduce the weight of, and improve the appearance of, such fittings as are used for gas. The introduction of the Inverted Incandescent Burner gave them their great opportunity, as with the burners in a pendant position they were able to introduce fittings that closely resembled the electric light fittings in appearance. The public also had a hand in the matter, as they in turn demanded gas fittings that were equal to the electric light fittings in appearance, and consequently designers with initiative were soon in demand.

The result is that to-day gas fittings are obtainable that do justice to any setting, and fit practically any scheme of lighting that can be imagined. To some extent the waste heat from gas burners was a source of trouble to designers of fittings, owing to the fact that it tended to discolour the high-class burners, which emit the waste products in such directions that they do not affect the fittings. On the other hand, use had been made of the potential ventilating effect of this waste heat, and we now have exceedingly ornate fittings that are fixed directly on to the ceiling and which, in addition to giving a very even illumination, utilise the waste heat from the burning gas to create a powerful ventilating effect. These burners are now largely used in churches, public halls, large offices, &c., with a very good effect.

For indirect and semi-indirect lighting electric light for some time held the field. The designers of gas fittings, however, soon overcame the difficulties of adapting gas to this form of lighting. In those fittings where the bowl is suspended by chains from the ceiling, the gas supply is carried to the burner or burners, which are not visible from below, by means of a flexible metallic tube looped through the chain. Burners were designed that would lie snugly inside the bowl, and there are to-day numerous very artistic semi-indirect gas pendants on the market.

Some features in which progress comparatively recently has been made are:—the introduction of small Upright Incandescent Burners forming imitation candles

for use on period fittings; the use of silk and bead shades; the introduction of rise and fall pendants other than the old water slide type, and the introduction of compact contrivances which enable gas to be switched on and off exactly as is the case with electric lighting.

The rate of progress during the last ten years has undoubtedly been much greater than at any other period in the world of science, and I think that this fact, coupled with the introduction of electric light, is responsible for the great progress made in the gas industry.

Mr. W. F. T. PINKNEY (*communicated*):—Mr. Thorpe has lightly and skilfully touched on many points covering a very large field, and any one of these points merits long discussion.

Of particular interest are Mr. Warren's remarks, and it is to be regretted that his opinions are not held by a greater number of his brother architects.

The indifference exhibited by a large number of architects to illuminating engineering is really extraordinary. It is a very common thing for an architect to design a building and to hand plans to a lighting engineer and ask him to prepare estimates for the lighting of such building, the cost not to exceed so-and-so (generally an inadequate amount), and no mention is made of the positions of the lights or the design of fittings.

It seems to me that this would have its parallel if the architect were to design the building without windows, and were to ask a glazier to give an estimate for installing windows, and the cost not to exceed a definite amount.

No architect designs his building without giving a careful consideration to the placing of the windows and the daylight illumination, and it is just as important that an architect should consider his artificial illuminations in the same way, and yet I know that it is not always done; in fact, I believe it is very seldom done.

I am quite sure that if all architects were to give more attention to the design of artificial lighting, and were to study illumination in the way it ought to be studied, they would then become more competent to design fittings of a decorative and efficient modern design to conform with modern architecture.

There are three classes of profession to which a fittings design is of great importance:—

1. The architect who generally lacks a knowledge of illuminating engineering.

2. The fittings designer, who is mostly concerned with what will appeal to the public (and who for this reason at the present time has to pander to the prevalent fashion of the antique), and who understands the requirements of the illuminating engineer, but does not always conform to his wishes.

3. The lighting engineer, who knows how to place his illuminations to get the most efficient lighting result from the point of view of brilliant illumination and small lighting bills. He, however, is scarcely qualified to tackle a question of design in relation to modern architecture.

It seems to me, therefore, that if the architect were to include in his curriculum of training a course in illuminating engineering, he would in time influence for the better the design of lighting fittings and all efficient illumination.

Mr. Trotter rather took exception to the word "fixtures." The lighting fittings have for almost all time been fixtures, and even the movable standard lamp is not used as much as it was some years ago.

Mr. Warren indicated the objection to flexibles, and practically asked for wireless transmission, in order that the chief objection to standard lamps might be got over. I am afraid we cannot look for that at the present time, but I venture to think that in domestic interior illumination much more use will be made in the future of the standard lamp and less of the wall and ceiling fixture fittings, as undoubtedly the mere fact that most fittings are fixtures is a great drawback.

Mr. Burt stated that the fittings designer experienced difficulty due to the present high voltage generally in use on Electric Supply Authorities' mains, for the reason that it was generally necessary to use high candle-power lamps. It is, however, quite possible to obtain low candle-power lamps for 200 to 250 volts, although these are not stock sizes and generally have to be ordered from the makers, but if the fittings designer were to create a demand for the low candle-power high voltage lamp, such lamps would very soon become stock lamps.

Mr. W. H. HOWLING (*communicated*):— Being an interested and appreciative listener to Mr. Thorpe's paper and the subsequent discussion on Tuesday evening last, I am inclined, with your permission, to put on record some thoughts that came to me during, and since the meeting. The art of design necessarily leads one on to debatable land, and the path of the designer is not inevitably smooth or level. Criticism, he finds, comes to him from people who may or may not be qualified to pass an opinion. Should he, in designing on the accepted lines of a "style" or "period," infuse too much individuality into his ideas, he is probably accused of "incorrectness." By the same school of thought he may be termed a "copyist" if he errs in the other direction.

Art being more or less constantly in the process of evolution, it must therefore follow that what meets with approbation to-day is, on the morrow, regarded with doubt. It is a far cry from the giants of Gothic and Renaissance times to the present day, but out of the continually varying phases that one notices now, it may be that some feature, at present unrecognisable by ourselves, will be hailed by our children's children as a conspicuous landmark in history.

The modern designer, especially if engaged in commerce, has to cater for a *clientele* of varying taste and capacity, he has therefore to be adaptable. My object in writing being the provision, in some measure, of food for thought, I will conclude with a quotation from Ruskin's "Seven Lamps of Architecture":—

"Frankness, however, is in itself no excuse for repetition, nor Audacity for innovation, when the one is indolent and the other unwise."

Mr. WALTER GILBERT (*communicated*):— In following Mr. Thorpe through the very interesting dissertation he has given on lighting, the point which particularly strikes me is—how comparatively easy a problem the old masters had in lighting to that which confronts us to-day. We must admit, however, that they accomplished their task thoroughly; their work was architectural—sound in construction, and their design exactly fell in with the materials necessary to obtain their luminant.

Their illuminants of oil or grease were concrete materials, and they evolved their fittings in a proper way by building their metal work and their woodwork round these essentials for their light.

This act of the old masters of lighting gave them inspiration in their methods of design and quickened their imagination, for their designs for lighting by oil are quite distinct from those they adopted for lighting by means of soaked wood rushes or grease.

To-day we are troubled with a plethora of materials and methods, so much so that we cannot make up our minds what scheme to adopt in making our designs. This plethora not only troubles us, but, what is more important, troubles the purchasing public. There are so many voices, each more or less shrill and insistent on being heard, each keen to give advice or express views, all excited owing to the amazing miracles of the inventions of these comparatively new lights of gas and electricity, that the designer has not yet been able to determine the true spirit of the luminant. He has turned candle fittings into gas fittings, and gas fittings into electric fittings.

I think, however, he realises that he has not yet done his part, for gradually he is becoming more courageous, and from having hung the electric bulb on to a piece of cord, he now by way of America rests the bulb in an alabaster saucer strung to the ceiling. I must say too that he seems very well pleased with himself at the thought that he is on the road to the discovery of an artistic and successful scheme of electric lighting.

There is no sounder axiom in art than "Study the old work," but this axiom has been the cause of delaying by many years successful modern lighting.

It has caused men to be content with the easier task of "cribbing" forms instead of evolving them—to work without thought instead of with imagination.

In lighting the American is far in front of us in this respect. Though in architecture there is no one to-day who more religiously copies old forms, in lighting there is no one more ready than the American to use his imagination either in the lighting of a room, a bar, a lounge, or a sky-sign. Their street lamps more

aptly fit the method of illumination than those I know in any other country.

The American understands that lighting, particularly electric lighting, gives him a power of appealing to the dramatic, the picturesque, or the splendid. He will light a dining table in such a manner that you will be able to see the dew-drops on the flowers, or make the table fountain (as in the Blue Room in the Casalle in Chicago) appear to you to have been stolen from Aladdin's Cave. He will hide his lights in blocks of frozen crystal or secrete them in vases of glowing alabaster (Morgan Library, New York); he will drop them as pearls hanging from trophies of the chase or the sea (Astor Hotel, New York), or smother them in baskets of luscious frozen fruits of glass (Windsor Hotel, Montreal).

I hear some rumours suggesting this to be bad art, but I personally do not see why a clever treatment of fruit in glass should be worse art than the treatment of ivy and finish of ivy in the round planted on the sides of the silver vessels of Roman origin which are considered to be among the treasures of the world in the Imperial Treasury at St. Petersburg.

This, then, is my text to the designer: Look upon the light as a jewel—dress and arrange the jewel as Holbein arranged his jewels, remembering that the jewel is the paramount feature, the setting to be subservient to the jewel and the jewel to be for the glorification of the person. The light-giving part of the fitting should be the predominant feature, the setting itself may be plain—it must be unobtrusive and subservient to the light-giving part—but the whole must be the jewel of the room.

Twenty years ago one man in England more nearly solved this idea, as any visitor to the late Sir Hubert von Herkomer's house at Bushey can confirm; if we advance with this thought in our minds I am convinced that we shall make a straight stride out of the somewhat stagnant pool in which we are to-day, towards a really defined and artistic period of design in lighting more in accordance with methods the wonders and advantages of which never in his wildest moments could have been deemed possible to the imagination of the old master.

Mr. H. T. WILKINSON (*communicated*):—I have read Mr. Thorpe's paper with much interest, and think it will do a lot of good. I am most interested in his remarks under "Modern Developments," and am of opinion that much may be done in the way of adapting old designs to modern requirements, thus embodying a beautiful appearance and efficiency in illumination. I think the present tendency is towards beautiful lines and proportions rather than detailed ornament. This, of course, applies more particularly to the industrial kind in general, and for modern room or office in particular.

I was over in Paris about two months ago, and was much interested in the electrical fittings used there. They are generally of the types profusely ornamented, and particularly those with festoons of prismatic glass. These in my opinion were all very well for the days of candles, but with modern high candle-power units they are altogether too dazzling.

They do not seem to have developed the indirect or semi-indirect methods as much as we have, and seem to adhere rigidly to their period styles.

The street lamp pillars in Paris are very fine, and it would add considerably to the beauty of our streets if we were not so painfully mechanical in our designs. I hope that borough electrical engineers may read Mr. Thorpe's paper, and take a lesson from it.

Again I would repeat that I think Mr. Thorpe's paper will do a lot of good, if it only induces designers to pay a little more attention to the desirability of embodying beauty and form, with efficiency, in modern fixtures.

Mr. MONTAGUE H. GALSORTHY (*communicated*):—I was unfortunately unable to be present when Mr. Thorpe was reading his paper on Lighting Fixture Design to which meeting you so kindly invited me, and it was only late yesterday I was able to get any time to read through his most interesting paper.

I think in connection with the Antique Boat Lamp, a point which is generally overlooked is the fact that it not only had an artistic appearance but was in olden times quite an efficient shape as

regards the lighting, that is to say that a container to carry the oil had to be embodied in the design and instead of placing this immediately under the lamp, which would to a certain extent blot out the light from below, people in those days were sufficiently ingenious to shape their lamps so that the actual burner came out at the end, avoiding shadow to a large extent.

There is no doubt that as regards period design the Flemish has held its popularity longer than any other particular style, chiefly in my opinion, due to its great simplicity. Such styles as emanated from the Brothers Adam, Sheraton, &c., have been revived from time to time of late years, and gone out of fashion again, due in a large measure to being overdone, and of late years especially has this been the case, having been absolutely killed by cheap and tawdry imitation. For instance, in cheap cabinet work as also in electric fittings it is only necessary to see a wretched so-called ram's head or a swagg with bows applied to some portion of the work to apparently justify the maker styling it Adams. Other periods coming into vogue in their turn have been killed off in a like manner until it makes one tremble to mention particular styles, unless you are dealing with an actual copy of some old piece made in the period in question.

I notice that the author states that most of the fine examples of glass work come from abroad and that the war is affecting this particular industry. I do not think he is correct. I should rather have said that the cheapest glass has hitherto come from Germany and Austria, and it is that particular glass that at the moment is not obtainable. I only wish that it might continue to absent itself from our markets. There is no doubt that some of the best glass work is carried out in this country. Unfortunately, from a commercial point this is greatly hampered by the workpeople themselves, who seem to be the masters in place of the employers.

I cannot see that there should be any objection to the use of electric or other modern illuminant being used in connection with Old English period fixtures. If the Brothers Adam were alive to-day they would have no hesitation in making

use of the modern electric candle or other lamps. It was only that they had no better form in their days than the wax candle from an artistic point of view, which caused them to lend their designs to that particular illuminant. The modern candle has a very soft and beautiful effect when lit and properly shaded, but I have come across many architects who taboo the imitation candle on account of its not being the real wax article, which after all caused a good deal of trouble due to wax dropping on to the floor. I am glad to find that a good deal of such prejudice has died out during the last two years. It is only another instance of our very conservative nature.

As regards semi-indirect and indirect lighting, this latter form never seems to me satisfactory. There are many instances of large shops and halls lit indirectly by metal bowls, suspended at intervals throughout the premises, and one never gets away from the impression of a number of dark blots in the general illumination, whereas in the semi-indirect form when properly carried out there should be sufficient reflecting power from the bowl to the ceiling combined with a certain soft light coming through the bowl itself. By this means a very restful and sufficiently brilliant form of lighting is to be obtained.

I do not think that the author has sufficiently alluded to the real cause for the modern demand of this form of lighting which is attributable to the high efficiency of the modern lamp, by which it has become practicable for people of moderate means to use this particular method of illumination, which a few years back would have been prohibitive owing to its costliness.

The use of alabaster for Domestic Lighting has been very popular of late, and I venture to think that it has come to stay. This material is not fit to be used in connection with gas, but there is no such trouble in using it with the Metal Filament Lamp, provided the lamp does not touch the alabaster, and I think that with this form of lighting, in spite of the author's remarks, there should be no difficulty in treating the illumination of old manor houses in the Tudor or other periods, the metal mounts of such fittings being carried out to correspond

with the style that has to be dealt with.

In regard to shop fronts, which the author does not seem to have alluded to in any direct manner, there is no doubt that the best form of lighting is that which throws the light on to the goods without being seen from the street. The writer wonders that this method does not become more popular than appears to have been the case. To look on a blaze of lights inside a shop not only is distracting to the eye, but takes one's attention off the goods exhibited in the window. The general idea no doubt hitherto has been to make a blaze of light in order to attract the public. If a strong illuminant must be obtained then it should be carried out in such a manner above the shop window as not to interfere with the interior of same.

In conclusion, I would like to congratulate the author on the large amount of information which he has handled so ably in his paper and the manner in which he has dealt with such a difficult subject.

MR. A. P. LUNDBERG (*communicated*):—Mr. Thorpe's paper is very interesting and well illustrated, but it does not touch on one point, viz.: the control of the light. This is a matter which has undergone even more wonderful changes than the designs of the fixtures; and it is also a matter which has been very little investigated by those most closely concerned.

There are still some people who, of their own free choice, prefer wax candles (not to mention oil lamps); and the only control possible with them is of the laborious point-to-point order, viz., individual lighting and extinguishing.

I would suggest that if architects, consulting engineers, and contractors were to give some attention to modern lighting controls—multipoint, variable, restrictive, pilot and so forth—they would find that the advantages and conveniences of electric lighting are immensely increased thereby.

There is nothing mysterious about these improved controls: they are not costly, and they form a logical utilisation of the properties of the electric system. In fact, I will go so far as to say that no electric-

light installation can be considered satisfactory till every consideration has been given to the manifold advantages of efficient illumination and convenient switching.

MR. F. W. WILLCOX (*communicated*):—Mr. Thorpe deserves our thanks for giving us such a concise summary or bird's-eye review of fixture design. He has made a difficult subject interesting by not limiting his discussion to the purely architectural and artistic features but by bringing in the utilitarian and practical points as well throughout.

I heartily endorse many of these practical points of his—in particular his remarks on the harm done by the failure of the architect to secure effective lighting arrangements for interiors of public buildings. It is particularly important that the artificial lighting of buildings should secure every attention in a climate like England's, where artificial light is required for such a large part of the working day in the autumn and winter season. It has always been an anomaly that an architect or owner of a building should expend so much skill and inquiry on interior architectural designs, and then leave the lighting of it to be so miserably and inadequately done.

London is full of buildings such as St. Paul's and many of the Government buildings in Whitehall, as well as office buildings and shops, that suffer lamentably from exceedingly poor lighting arrangements. The buildings suffer as well as the people who visit or occupy them.

In respect to fixtures generally a reading of Mr. Thorpe's excellent paper leads me to consider whether the time has not come when we are to depart materially from the cult of the lighting fixture itself.

A brief explanation will indicate what I mean.

The essential intention of a lighting fixture or fitting is to provide a suitable support or mounting for the illuminant. The original design was thus determined by the early illuminants, which were flame illuminants, and therefore had to be supported in an upright position well below the ceiling.

Now the trail of this idea—what I may call the "fixture idea"—has been over

the lighting industry ever since. The introduction of the electric light—the flameless illuminant—has completely altered the original requirements. A considerable part of the time since the introduction of the electric light has naturally been given over to adaptations of the previous existing fittings and ideas to this system of lighting; but the time has come when, with the wide employment of electric light, the old-established fixture or fitting idea must pass. There are already widespread indications of this change, particularly in the newer countries such as the United States and Canada. In general it may be said that the central type of “arm fixture,” as it may be called (*i.e.*, fixture with arms or branches),



Modern Lighting without Fixtures.

Concealed lighting of church chancel showing how the architectural details can be portrayed and a perfectly natural lighting effect secured.

is becoming obsolete. Its place is being taken by some form of a bowl—either glass (semi-indirect) or metal in plaster (wholly indirect). Such an evolution is being hastened by the improvements in efficiency of the incandescent electric lamp. These latest lamps, such as the “half watt” lamp, have a very great increased brilliancy, and their proper use compels some form of indirect lighting.

Let us agree that branch arm fixtures should form an essential part of any architectural scheme where the character of the illuminants (flame-type) or any other practical necessity requires the use of such a fixture. We must, however, depart from the fixed programme that the fixture idea must form a part of every architectural scheme or construction and that everything—form of illuminant, method of use—must be subordinated to the fixture. We must not be bowed down to always consider that a fixture, for example, must be suspended from the ceiling somewhere about the interior. We should not consider, in other words, that a fixture is necessary purely as a piece of furniture in any part of the room such as a door or chair. In the case of electric light that time has gone by. Modern lamps and methods no longer require the use of the primitive idea of a suspended candelabra or bunch of metal arms in the centre of the room. Furthermore, the high brilliancy of the latest electric lamps (the economical working of which will compel their adoption) require such radical modifications of the existing fixtures as to suggest their entire elimination in the case of many interiors.

To employ invariably old arm fixtures encumbering the centre of a room, purely because such fixtures were a necessity of the period in which the room is designed, seems to me to be placing modern developments and advances under too heavy a restriction; and some of the modern lamps are too brilliant to permit it. It would seem to be on a par with requiring that the old water-clocks should be used in place of modern timepieces in analogous cases.

It seems to me, therefore, that the time has come when period designs in fixtures should be subordinated and that the requirements of the most efficient lamps will produce such difficulties and anomalies in the use of period fixtures as to eliminate the fixture entirely.

I might elaborate on the benefits that will be gained both architecturally and artistically by the removal of the heavy fixture from the centres of many rooms and interiors. The advantages to the art of illumination and the benefits in improved lighting will be very marked,

as illuminating engineering has always suffered from the trail of the fixture over the industry.

The passing of the fixture would leave us with a clear ceiling and unobstructed space overhead. It will increase the vogue of natural and unconscious lighting and concealed lighting in all its forms; it will achieve the elimination of glare and all the derived evils of bad lighting; will diminish the tendency to bad eyesight and nervous troubles due to unsatisfactory lighting conditions; and finally will lead us away from the too slavish following of old period designs. All this will come about when the art of interior illumination is freed, as it should be, from conventions of style and period.

Mr. F. W. THORPE (in reply):—The excellent discussion on my paper has turned mainly on the true relationship between the practical and the æsthetic, in design. From the teaching of men like Ruskin and Morris, these principles are well known to every designer. But the fact remains that he is prevented from rigidly practising those principles, by the prevailing want of knowledge of his clients, for whose requirements he has to cater. Nevertheless, it does not follow that the designer is necessarily a slave to that ignorance, nor content to have it so.

It has been suggested that the only way to overcome these restrictions and obtain independence of thought is to provide something better, ignoring the claims of the unenlightened. But it may be pointed out that the policy of "splendid isolation" is only possible to an independent artist who is unembarrassed by considerations of £ s. d. We cannot ignore the changed conditions represented by the fact that objects of art are now produced on a commercial basis, and have to meet the requirements of an undiscerning majority. The designer practising idealistic principles would find the smallest possible market open to him. He no longer works for a small circle of "patrons"; nor in these democratic days would we desire it. His field is now the public—in fact, the world.

His mission, then, is firstly of a checking nature, and secondly, educative, and this, like every other form of education,

is gradual. We have evidence that this education is actually in progress by the great improvement in fixture design during the last few years. And we hope to carry on the work.

Much has been said on the compromise between efficiency and artistic effects. These aims are not necessarily conflicting; many of those who criticise period fittings have apparently in mind obsolete types, such as no good designer would produce now. Similarly, one would naturally aim at congruity with surroundings, and my remarks on adherence to old models do not imply that I advocate retaining their defects, or approve of certain designs for indiscriminate use amidst modern surroundings. The lamp illustrated embodying the sacred monogram is not, as Mr. Warren seems to suggest, put forward for general use. It is not usual to attach religious symbols to objects intended for secular use.

Turning to modern tendencies in design, it is surely a mistake to advocate the use of one system—direct, indirect or semi-direct—for every purpose. The best installations are those in which the lighting system is adapted deliberately to meet the needs of the interior. Those who criticise the retention of period fittings and advocate indirect lighting should also bear in mind that this system involves waste of light and is, in a sense, a confession that the modern lamps frequently yield an inconveniently high candle-power and brilliancy and that the engineer has not yet succeeded in developing the ideal lamp for purposes of illumination.

Nor should it be too rashly assumed that the ideal in artificial lighting is to simulate daylight. Artificial illumination has a charm of its own and it is surely questionable whether it is desirable either from the artistic or physiological standpoint, to imitate natural light exactly.

Finally, I must thank those who have joined in the discussion for their kind reception of my paper.

ERRATUM.

Illuminating Engineer, Feb. 1915, pp. 72-75, for "H. H. Johnson" read "*J. H. Johnson*."



TOPICAL AND INDUSTRIAL SECTION.



[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

A NEW SERIES OF REFLECTORS FOR INDUSTRIAL LIGHTING.

At the invitation of the British Thomson-Houston Co., Ltd., a visit was recently paid to Mazda House in order to inspect the new range of Mazdalux metal reflectors for industrial lighting. During the last few years there has been a great advance in methods of factory lighting, not the least important step being the introduction of standard types of reflectors designed to screen the source and distribute the light in a predetermined scientific manner.

The new series of Mazdalux reflectors appears to represent a distinct advance on the previous reflectors of this kind. There are now available reflectors specially designed for "half-watt" as well as ordinary metal filament lamps, ranging in candlepower from 10—3000. For each size of lamp reflectors giving no less than *ten* distinct characteristic distributions of light, as illustrated in the accompanying table, can be obtained.

The reflectors are available in three classes of finish, namely aluminium with special matt aluminium interior reflecting surface and French grey enamel outside; steel with similar finish; and steel with white vitreous enamel both inside and outside. There are also eight styles of caps or housings available for all types of lamps up to date.

What, however, struck us as the most interesting feature is the elaborate way in which the characteristic qualities of each reflector are tabulated and catalogued. Attached to each reflector is a label giving full data, distribution curve, size of Mazda lamp to use and instructions for correct installation.

The Mazdalux price list gives some interesting data including an article on "How to plan lighting installations." As this information will fit in more suitably with the contents of our next issue we mean to deal with it more fully on that occasion, and to illustrate some typical reflectors while doing so.

Form of Distribution.	Angle of maximum ray.	Spacing for even illumination.	Angle of cut off.	Maximum cp.
Dispersive V.E. ..	30 deg.	2 times	90 deg.	1.75 times
Extra Extensive ..	60 "	2.5 "	85 "	1.4 "
Extensive ..	25 "	2 "	80 "	1.5 "
Intensive ..	25—40	1.5 "	75 "	1.7 "
Focussing ..	0 deg.	1 "	65 "	2.75 "
Concentrating ..	0 "	1/2 "	55 "	4.5 "
15 deg. angle ..	15 "	1 "	75 & 105 deg.	2.5 "
30 deg. " ..	30 "	1 "	65 & 115 "	2.5 "
45 deg. " ..	45 "	1 "	55 & 135 "	2.5 "
90 deg. " ..	90 "	1 "	20 & 160 "	2.5 "

"EDISWAN" HALF-WATT LAMP FITTINGS.

A leaflet from the Edison and Swan United Electric Light Co., Ltd., describes some of the Company's new half-watt fittings.

The lantern shown is for interior and exterior use, and is stated to be water-proof and efficiently ventilated.

A feature is the special form of adjustment to counteract any variation in the length of the lamps for which it is intended.



G.E.C. ELECTRIC LIGHTING FITTINGS.

WE are interested to note that the **General Electric Co., Ltd.**, making an improvement in the factor of safety of their electric lighting fittings by discontinuing the use of Nos. 38 and 40 gauges and instead using such a number of strands of No. 36 gauge for flexible cords, as to give the equivalent section in solid copper.

In this way the tensile strain on flexible cords will be considerably diminished. Although a detail in design, it is by no means an unimportant one.

Messrs. **Siemens Bros. Dynamo Works Ltd.** have received an acceptance of their tender for the supply of Wotan, Tantalum and carbon filament lamps from Messrs. G. Thompson & Co., The Aberdeen White Star Line, 7, Billiter Square, E.C.

Established
1885.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.
Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES

Of Life Assurance, with Various Options

All Classes of Insurance Business Transacted

CHIEF OFFICES:

General Buildings, Perth, Scotland.
General Buildings, Aldwych, London.
General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, March, 1915.

Editorial	L. GASTER	97
-------------------	-----------	----

Illuminating Engineering Society—

(FOUNDED IN LONDON, 1909.)

Account of Meeting on February 16th, 1915	101
New Members	101
Some Notes on the Development and Design of Lighting Fixtures in relation to Architecture, Interior Decoration and Illumination .. By F. W. Thorpe ..	103
<i>Discussion</i> —J. Darch—A. P. Trotter—E. P. Warren—J. S. Dow—P. J. Waldram—C. H. Burt—J. G. Clark—Percy L. Marks—A. E. Penn—Frank Bailey (Chairman)—F. T. Cash—W. D. Helps—W. F. T. Pinkney—W. H. Howling—Walter Gilbert—H. T. Wilkinson—M. H. Galsworthy—A. P. Lundberg—F. W. Willcox—F. W. Thorpe	
	120—144

Topical and Industrial Section—

A New Line of Reflectors for Industrial Lighting	145
Ediswan Half-Watt Fittings	146
Insurance Coupon	147
Two Siemens Installations	148
The Beuttell System of Fixtures	148

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL

ACCIDENT FIRE AND LIFE

ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.

GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.

F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that, being dated, forms the only evidence of its currency.

TWO SIEMENS INSTALLATIONS.

Messrs. Siemens Bros. Dynamo Works, Ltd., send us two illustrations of installations which show, in an interesting way, how both the traditional fixture method of lighting and the more modern arrangements of hemispheres, &c., are used at the present time.

It is an interesting question how far the latter method will replace the former. Meantime, modern illuminants are being adapted to both.

The first of these pictures shows the use of imitation candles on a cut-glass chandelier, the second the use of Wotan metal filament lamps in Holophane prismatic glass hemispheres and reflectors.

THE BEUTTELL SYSTEM OF FIXTURES.

We had recently an opportunity of inspecting the Beuttell system of fixtures, which have been worked out in an ingenious manner to make use of the tubular lamp. The ideal source of light for optical purposes would doubtless be a point source, but it is possible to control the distribution of light from a line source in quite a remarkable manner.

Some of the units on view include special reflectors for lighting show-windows, posters, and for theatre foot-lights, and there are others (such as the "sunburst" unit) which depend on the principle of oblique illumination of a mat white surface, which in turn becomes the distributor of light.

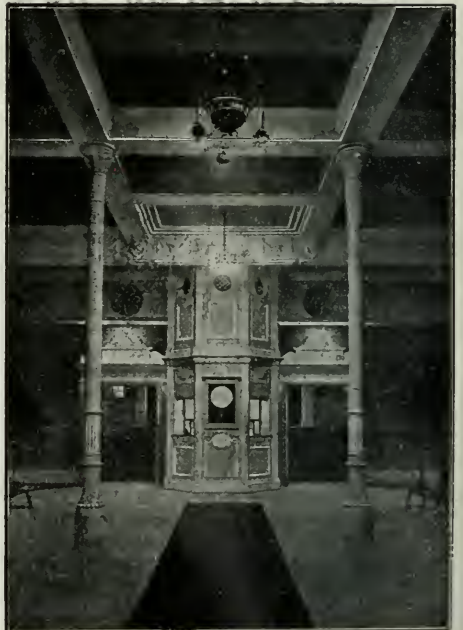
PERSONAL COLUMN.

Mr. V. H. Mackinney, one of our active members in the Illuminating Engineering Society, is now in Sydney developing the Australian branch of Holophane, Ltd. The present is surely the moment to stimulate an interest in British-made scientific lighting appliances, and we understand that the illuminating engineering movement is receiving a considerable amount of attention in that country. Mr. Mackinney carries with him the best wishes of all his friends.

Members of the Illuminating Engineering Society will be interested to hear that Mr. W. J. Liberty (Inspector of Public Lighting of the City of London) who, at the commencement of the war joined the Royal Naval Reserve Volunteer Anti-Aircraft Corps, has now been transferred to the Royal Naval Air Service (armoured car section) for "special service on the East Coast."



Cut-Glass Chandelier. Entrance Hall Fitting.



Hall lighted by Wotan lamps in Holophane glassware.



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.

32, VICTORIA STREET, LONDON, S.W.

Tel. No. 5215 Victoria.

EDITORIAL.

The Grading and Marking of Lamps.

The question of the grading and marking of lamps, discussed at the last meeting of the Illuminating Engineering Society on March 16th, is an exceedingly important one, both to manufacturers and to consumers, who look much more closely into the performances of lamps supplied to them than they formerly did. The importance of the matter was pointed out by the writer in an article in the *Times Engineering Supplement* as far back as October 25th, 1905. It is obviously desirable that some common procedure applicable to all illuminants should be followed, and the question is one that must be settled on broad lines. We have to strike a compromise between what the lighting engineer would like done, as ideal, and what the manufacturer can conveniently do.

In the first place a distinction—which is perhaps not generally appreciated—should be drawn between the “rating” or, more correctly, “grading” of lamps, and the “marking” of them. By the *grading* of lamps is meant the manner in which they are classified by the manufacturer in an ascending series by consumption or candlepower; by *marking* is meant what is actually marked on the lamp handed to the consumer. In considering this question the difficulties of the manufacturer have to be

very clearly recognised. Few people, for example, who are not directly brought in contact with the manufacture of incandescent lamps realise the large number of processes involved in the finished product. At each stage in the process there will inevitably be a certain number of "throw-outs," and therefore, in specifying the requirements of the final lamp, a reasonable degree of latitude must be allowed, or higher prices paid for specially selected lamps.

At present, largely no doubt on account of the greater precision with which consumption of gas and electricity can be measured, manufacturers prefer to grade their lamps on this basis rather than in candlepower.

To the consumer a series of lamps taking 10, 15, 20, 25, 30 watts is more useful than the old system of rating as 8, 16, 32 candlepower, the gaps in which are too big. It has sometimes been objected that on this system the consumer could not take the best advantage of improvements in efficiency; for this improvement would merely lead to a series of lamps taking the same consumption as before but yielding more light. But a little consideration shows that if the intervals between successive lamps are small the consumer can readily reduce his consumption by adopting a smaller lamp in the series, at the same time maintaining the desired illumination.

On the whole, therefore, we consider that this system of grading lamps by consumption, which appears to have become general during recent years, is no hardship to consumers, provided the latter is afforded sufficient additional data as to the performance of the lamp in practice.

We now come to the second point—the marking of lamps. In the discussion before the Illuminating Engineering Society there was a general agreement that the consumer should be informed, both of the input in energy and the output in light. He wants to know the amount of gas or electricity that will be consumed, and what he will have to pay for it. But he should also have particulars as to the amount of light which he will obtain as a result. The requirements of the illuminating engineer are somewhat more precise than those of the general public. The former requires additional data such as the polar curve showing the distribution of light. In the majority of cases the lamps will be equipped with a reflector so that he must utilise, in his calculations, the polar curve of the finished unit. But in many instances it would also be an advantage to him to have the polar curve of the lamp alone, as this is useful in drawing conclusions as to its effect in combination with any particular reflector he has chosen or already possesses. Moreover, modern electric lamps possess such widely different distributions of light that a knowledge of their polar curves is really essential in order to draw any valid comparison between them. We think, therefore, that it would be well for the polar curves of typical lamps, as well as combination units with reflectors, to be given in the catalogue literature. We were glad to see the recognition of the need for such data, among both users and manufacturers, and that our suggestion that standrad types of lamps and lighting

appliances should be tested at the National Physical Laboratory met with approval. We would also suggest that when particulars of lamps and units are printed on boxes, labels, or wrappers accompanying them, the polar curve should be included. This practice is now being developed by one of the leading companies and could easily become general if demand is created for it.

It is essential that the illuminating engineer, in making use of such data, should feel confidence that the information afforded is comparable and strictly correct. For this reason we emphasise the valuable work the National Physical Laboratory could do in making these tests. Naturally the exact procedure for these tests would have to be carefully considered in order to guard against any possible misuse of the information supplied. But we think that these details could be satisfactorily arranged.

For the ordinary consumer the question of the information to be marked on the lamp itself is of importance. From a scientific standpoint much can be said for the view that either the total flux of light in lumens or the mean spherical candlepower should be indicated. This affords the most satisfactory comparison between different units, in terms of the total light available. Mr. Willcox has advocated strongly the adoption of the lumen-basis. In the United States, where lamp makers, supply companies and large consumers are in close co-operation, this method has found favour; as comparatively few people have to be consulted, such changes are more easily brought about there than here. In this country it would probably be difficult, as far as the general public is concerned, to depart from candlepower and substitute the lumen at present.

We are therefore inclined to suggest that for the sake of general comparison the mean spherical candlepower of sources should be given, and might be marked within a circle thus : (50) to indicate that the number refers to the mean spherical value. On the other hand, it has been suggested that for those of the public who do not readily understand polar curves the candlepower in the maximum direction should be indicated.

It should be understood that for manufacturing purposes considerable latitude would have to be allowed in the interpretation of these data. But even so it would be clear at least what the figures were intended to convey, and we should avoid the confusion of exaggerated claims based on candlepower in a special direction which have not infrequently proved troublesome, alike to manufacturers and the public. During recent years the electric incandescent lamp industry has become more fully organised, and these problems can now be considered with greater prospects of success than was formerly the case.

No doubt this discussion before the Illuminating Engineering Society will be helpful in enabling the standpoints of the various parties interested to be more fully appreciated, and will be borne in mind by the various committees interested in this matter.

Collective Advertising.

During the past month a series of articles by well-known authorities has appeared in the *Daily News* under the heading "Business Opportunities." Included in this series was a contribution from Mr. F. W. Goodenough describing the development and work of the British Commercial Gas Association. The activities of the Association represent one of the best examples of "collective advertising" in this country. The movement appears to have been suggested by the experience of the Gas Light and Coke Company, that their advertisements in various papers not only stimulated the demand for gas in their own London area but affected to a remarkable extent the business of provincial gas companies. At the present time the publicity work of the Association covers a wide area, and its influence is felt from John o' Groats to Land's End. Every gas company must confine its activities to its own area, but the collective advertising of the Association reacts in all directions so that all derive benefit. The movement, it is stated, has even been copied by the National Commercial Gas Association in the United States, where co-operative enterprise has long reached a high stage of development.

We have referred specially to the work of the British Commercial Gas Association as a noteworthy instance of what co-operative effort can accomplish. In this case the direct results of publicity were clearly visible. But we venture to think that the unseen and untraceable effect has been even greater. The lighting industry in this country is only now beginning to appreciate how much might be done by concerted effort.

We would like to see the electric lighting interests developing a publicity scheme similar to that prompted by the British Commercial Gas Association, thus encouraging healthy competition.

During the last few years lighting has come to occupy a distinctly higher place in the public estimation, but, this is nothing to what may come in course of time. Few people probably appreciate the strain of the patient educational work done by the movement for the industry during the past few years. It goes without saying that years of perseverance are needed before the initial inertia of people towards a new movement like this can be completely overcome. We can, however, already see results and we think that the present circumstances, inconvenient as they may be felt to be, are just those in which preparation should be made for the future. It is a mistake for the non-combatant section of the population to acquiesce in a passive attitude and "let things slide." It is their duty to make, if possible, greater efforts than usual to keep the machinery of industry intact, and to plan for the future so that those who have gone to the Front may find work waiting for them when they return. The British Commercial Gas Association, in deciding to continue their publicity with added vigour, have done the right thing. We count on the support of our friends to ensure that the illuminating engineering movement is likewise not allowed to suffer, and that the chain of continuous effort is maintained until brighter times arrive.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

A METHOD FOR DETERMINING THE RANGE OF SEARCHLIGHTS.

BY PROF. A. BLONDEL.

(Continued from page 90, February, 1915.)

GRAPHICAL SOLUTION OF EQUATIONS.

The simplest method of dealing with the above equations is to make use either of an Abacus with parallel scales or Cartesian co-ordinates.¹

(1) *Abacus with Three Parallel Equidistant Scales.*

Assume $R=0$ and a known. On the central scale graduated in respect to I , we plot values of $\frac{1}{2} \log I$; on one of the other scales graduated in respect to the variable x we mark out values of the first term in the equation (6); on the third scale graduated in terms of the function of x_1 we mark out similarly values of the second expression in the equation. Once the three scales are prepared it is only necessary to draw a line joining corresponding points on the outer scales. Where this line cuts the central scale we can read off the value of $\log I$, and thus deduce I . Conversely if we assume a value for I we have to find values of x and x_1 such that $l=x-x_1$. If we know that $l=0$ (i.e.,

that the observer is at the same distance from the mark as the projector) we omit terms containing $\log a$ in one of the parentheses in the second member of the equation, and we have only to consider a on one of the scales; also one can take the same x for both scales.

The introduction of the term $[R]$ is effected by a translation of the scale for I along itself, downwards.

One may also trace out another couple of outer scales when it is necessary to consider a as a variable.

A similar type of abacus can be used to solve equation (2) in terms of E' , I and x .

Equation No. 6 may also be put into another very general form by putting $x_1=x-l$ and separating the second member in the equation into three terms in parentheses, thus—

$$\log I = \left(\frac{x}{gL} + H \right) + (2 \log x + 2x [\log a]) + \left([R] - \frac{l}{gL} - l [\log a] \right)$$

$[\log a]$ being the modulus or absolute value of $\log a$.

¹ Following the "nomographic" methods of M. d'Ocagne.

If we suppose the final term to be *nil* the equation will indicate the value of $\frac{1}{2} \log I$ measured on the central scale, which will be a mean between the values of the two first bracketed terms, measured out respectively as lengths on the two extreme scales; these scales being graduated in terms of x , while the central scale is graduated in terms of I .

Any introduction of a difference in the distance, l , will be equivalent to displacing the scale, I , along itself, the displacement upwards being

equal to $\frac{l}{gL} + l[\log a]$. On the other hand

the use of glasses, which is specified in the term R is introduced very simply by displacing the scale downwards through a distance equal to $[R]$.

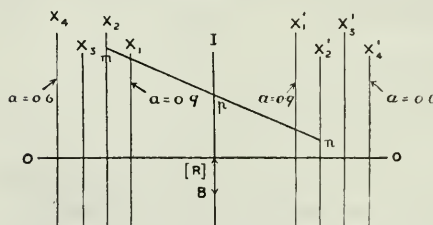


Fig. 1. **Abacus with three linear scales.** OO origin line of the three scales. I scale of candlepower expressed in megacandles; this scale carries values of $\frac{1}{2} \log I$. The scale can be so arranged that the zero falls above OO at a point B such that the absolute value of $AB=[R]$. The values carried by the scale x_1 are equal to $2 \log x + x [\log a]$, with $a=0.9$. Similarly x_2, x_3, x_4 correspond with other values of a , namely x_2 for $a=0.8, x_3$ for $a=0.7, x_4$ for $a=0.6$. x'_1, x'_2, x'_3, x'_4 are vertical scales symmetrically placed with regard to x_1, x_2, x_3, x_4 on the other side of the central scale I , and are graduated with reference to x_1 . For the four values of a , the lengths carried by these scales represent the quantity

$$\frac{x'}{gL} + H + x' [\log a]$$

mn is a straight line by the two values x and x_1 , traced respectively on the two scales x_2 and x'_2 ; both corresponding with a coefficient of transmission $a=0.8$. The intersection of mn on the scale I gives a point p and the corresponding value of I is read off on the scale at this point.

The two extreme scales, which are utilised for the functions of a are used in just the same manner for other values

of a , the only condition being that they should be symmetrically placed with regard to and equidistant from the central scale dealing with a function of I .

Abacus in Cartesian co-ordinates.

The equations (7) and (8) can be readily adapted to Cartesian co-ordinates. It is sufficient to mark out the abscissa in terms of x and the ordinates in to be graduated in terms of $\log I$, calculated from the equation after having suppressed the term R in the second member of the equation. One could also operate by suppressing the term $x \log a$. We should thus obtain a curve:—

$$\log I = \frac{x}{gL} + H + 2 \log x$$

applicable when $\log a=0$, i.e., when $a=1$. If $a<1$ it is necessary to replace the abscissa axis by an oblique axis OD inclined at an angular coefficient of $2 \log a$ for equation (7) or $\log a$ for equation (8). Once the scales and the axes are determined, one can read off, with oblique co-ordinates values of I corresponding to values of x and *vice versa*.

The term $[R]$ involves a simple translation of the scale for I towards the base. Similarly, if x and x_1 are not equal, one may add a second member to equation (7) namely a term

$$-l \left([\log a] + \frac{1}{L} \right)$$

It will therefore be necessary to give the scale for I a shift upwards of

$$+ \left([\log a] + \frac{1}{gL} \right)$$

This construction is quite practicable even if visual acuity does not follow the law of Fechner, for one can always trace the curve of $\log I$ experimentally as a function of l , as has been explained above.

The method discussed in the above analysis seems to solve, as completely as one can expect, the problem of determining the range of a projector in practice, Engineers and officers employing this

construction have only to determine the various empirical constants and can then construct by their aid the scales required to suit the local circumstances.

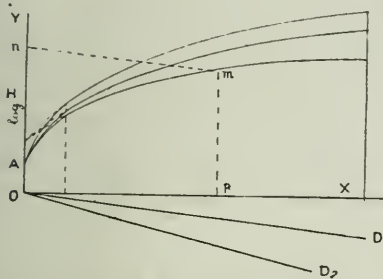


Fig. 2. **Cartesian Co-ordinates.** On the scale of ordinates OY the logarithms of I are marked out, and the scale is graduated in terms of I . The abscissa OX carries values of x and the scale is graduated in terms of x . ABC represents the relation

$$\log I = \frac{x}{gL} + H + 2 \log x.$$

In this case $a=1$. OD_1 is a straight line making an angle β_1 with OX such that $\tan \beta_1 = \log a_1$. Similarly the line OD_2 makes an angle β_2 such that $\tan \beta_2 = a_2$. The ordinates compressed between OX and any line OD represent the term $2 \times \log a$.

The curve $A_1B_1C_1$ is obtained by adding to the ordinates of ABC a supplementary term $= 2x \log a_1$, a_1 being given any desired value a_1 , for example $= 0.9$. $A_2B_2C_2$ is obtained similarly with a different value, a_2 .

If one only wishes to make use of the curve ABC, with $a=1$, and to dispense with the construction of the others, it is enough, for all other values of a to replace the horizontal axis OX by a corresponding oblique axis OD. For example the line mn has been traced parallel to OD_1 . The ordinate On represents the candle-power necessary to enable an object situated at a distance x , corresponding with the abscissa Op, to be clearly seen (with $a=a_1$).

ANOTHER FORM OF THE RANGE EQUATION.

Let us consider again the equation for the range of a projector established above :

$$\log I = \left(\frac{x_1}{gL} + H + x_1 [\log a] \right) + (2 \log x + x [\log a]) + R. \quad (6 \text{ bis})$$

in which $[\log a]$ and $[R]$ are moduli of the algebraic quantities $\log a$ and R , which are always negative. L and H are two associated constants, which can

have two sets of different values, L_1 and H_1 , or L_2 and H_2 , according as the illuminated object is observed with an acuteness of vision above or below a certain critical figure.

In the first parenthesis of the second member of the equation one can, by assembling together the logarithms, write :—

$$\frac{x_1}{gL} + x_1 [\log a] = x_1 \log \left(\frac{a}{10^{\frac{1}{gL}}} \right). \quad (6 \text{ ter.})$$

10 being the base used for the logarithms.

The effect of the term $\frac{x_1}{gL}$, allowing for

the acuteness of vision, is then the same as if the coefficient of transmission a , which intervenes in the path of the rays from the object to the observer, were replaced for this range x_1 by another fictitious coefficient of smaller

$$\text{value, } a' = \frac{a}{10^{\frac{1}{gL}}}, \text{ or } a'' = \frac{a}{10^{\frac{1}{pL}}}, \text{ as the}$$

case may be. The effect of acuteness of vision in the question of the range is thus analogous to the effect of atmospheric transmission.

But as soon as one introduces the coefficient a' defined as above, the constant $H = \log E_0$, specifying generally the minimum illumination necessary for the perception of form, becomes a constant of minimum illumination applying solely to the nature of the object observed—however small the acuteness of vision required may be.

From equation (6) we can derive the equivalent algebraic equation :—

$$I = \frac{E_0 x^2}{a^x (a')^x} \cdot \left(\frac{1}{k \frac{d^2}{p^2}} \right)$$

which can replace the expression given in the last number (p. 87) relating the candle-power of the source I and the apparent illumination E' or more precisely :—

$$I = \frac{E' x^2}{a^x + x_1 \left(k \frac{d^2}{p^2} \right)} \quad \dots \dots (10)$$

The above considerations will serve to show the important part played by

acuteness of vision in the interpretation of observations and results.

In practice the equation (6 bis), where $H = \log E_0$, is preferable.

The use of a fictitious coefficient of transmission a_1 no longer allows of the very convenient correction which I have indicated, as a means of allowing for the cases in which x is respectively equal and unequal to x_1 , namely, a simple translation of the scale transposing a^{x+x_1} into

$$\frac{a^{2x}}{a^{x-x_1}};$$

whence $(x+x_1) \log a = 2x \log a - l \log a$.

UNITS.

The units to be employed in researches on projectors are the *kilometer* for the unit of length, and the *lux* as the unit of illumination; the homogeneity of the formula involves the use of the "*megacandle*" (equal to one million candles) as the unit of candlepower. The *unit of acuteness of vision* employed by physiologists is that acuteness which enables printed letters, the breadth of which subtends five minutes and the thickness of the lines composing them one minute, to be clearly distinguished. The corresponding angle in radians is $\frac{1.45}{1,000}$,

equivalent to the angle subtended by a height of 1.45 metres at a distance of 1 kilometre. The constant $L = Bb$ is the product of greatest length in metres of object observed, b , and the constant B .

We can thus deduce the value of the acuity as a function of normal acuteness of vision for an object of height b , seen at a distance of one kilometre,

namely $\frac{1.45}{b}$, b being measured in

metres: this constant will be unity when the acuteness of vision is normal at an illumination of 1 lux.

ORDER OF MAGNITUDE OF B .

According to Koenig's researches it would be about 0.43 for cone-vision and approximately only 0.043

for rod-vision. Hence in our formula we shall have $B = \frac{0.43}{1.45} = \frac{1}{3}$

(whence $\frac{1}{Bb} = 3$), when the acuteness of vision is in the upper limit (above 0.15) and the cones are in use. If, for example, an object gives rise to an acuity $V = 0.20$ at 1 kilometre, $\frac{1}{Bb} = \frac{3 \times 0.20}{1.45} = 0.41$.

For acuteness of vision of the lower order (below 0.15) we should have $B = \frac{1}{30}$ about, whence $\frac{1}{Bb} = \frac{30}{b}$.

SIGNIFICATION OF THE CONSTANT L .

The meaning of the constant H has been explained above, but it is important to consider that of the constant L , which has the dimensions of length. When one observes with the naked eye, and in a perfectly clear atmosphere, the equation (4) of p. 89 may be written:—

$$\frac{x_1}{L} = \log \frac{E}{E_0} \dots \dots (4 \text{ bis})$$

We have, therefore, $x_1 = L$ when $\frac{E}{E_0}$ is equal to the base of the logarithms employed, in the case 10. L is thus the distance at which one can see an object having a visibility just sufficient for the perception of form, when it is submitted to an illumination equal to ten times the ordinary illumination E_0 . This definition of the constant L has the advantage of eliminating the length characteristic of the object, b , which may often prove difficult to define. The formula for range then assumes quite a general character, granted that the constant L can be determined by direct observation.

DETERMINATION OF CONSTANTS.

E_0 and L can be obtained by tracing the line of points relating x_1 and L according to equation (11), $x_1 = L \log (E - H)$, x_1 being the ordinates and $\log E$ abscissæ. L is then the inclination of the line and H the intercept from the origin on the abscissa. This will be always positive for cone-vision, but may be negative in the case of rod-vision.

I have already suggested the methods of making this determination (p. 89).

Practical limits of the values B and H.

The point of transition between the two cases corresponds to a value for the normal acuteness of vision about 0.15, and it is interesting to examine some practical examples in order to determine whether or no this value will be exceeded.

It may be recalled that normal acuteness of vision implies the power to distinguish those objects whose greatest length is not less than 1.45 metres at a distance of one kilometre.¹ In practice a troop of infantrymen having an average height of 1.75 metres should be visible at a distance of at least 500 metres.

This is equivalent to an acuteness of vision of $\frac{1.45}{1.75} \times \frac{500}{1000} = 0.41$ of the normal

At 250 metres the acuteness of vision called for would be reduced to 0.20. In practice vision is achieved almost exclusively by the cone-area of the retina. If artillerymen observe the above troop of infantry by the aid of glasses, having an average magnification of 8, the distance of observation might be 10 times as great.

Again, take a farmhouse 6 metres high is observed by artillery (without using glasses) at a distance of 10 kilometres, the acuteness necessary is

$$\frac{8}{10} \times \frac{1.45}{6.00} = 0.20 \text{ about.}$$

It is thus evident that in the use of projectors on land the constants B and H to be determined involve cone-vision.

The same would apply to observations at sea when one is examining objects of the order of magnitude 6 m. $\times$ 1 m. 20 on ships, with a telescope having a magnification of 10, and at a distance of 10 kilometres.

Only the scouting work of the navy (torpedo boats, submarines, &c.) would call for rod-vision, when the necessary acuity falls under 0.15.

Another case in which one meets with rod-vision is furnished by work with the headlights of automobiles and locomotives. Here the range of observation

does not exceed 500 metres, and the objects to be recognised are usually men, vehicles, &c., the height of which always exceeds the normal value of 1.45 metres.

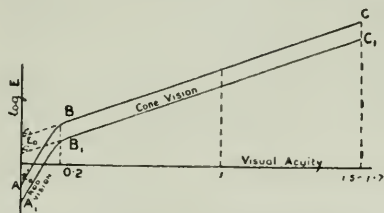


Fig. 3. **Acuteness of Vision Curves** (Double Law of Fechner) as a function of the illumination (after Koenig). ABC, $A_1B_1C_1$ are two curves corresponding with two distinct types of objects. AB and A_1B_1 , approximately linear and parallel, correspond with rod-vision. (By red light the inclination of these lines would be less.) BC, B_1C_1 , also approximately linear and parallel, correspond with cone vision. (By blue light the inclination of these lines would be steeper.) C, C_1 are the maximum limits of acuteness of vision, which vary according to the observer (being, according to Koenig, 1.5—1.7).

E_0 , E_0' represent the minimum illumination according to Fechner's Law corresponding with the ordinate intercepts of BC and AB respectively; θ , θ' the corresponding inclinations with the ordinate axis.

Tang. $\theta = B$, a constant. $\log E_0 = H$, a constant
Tang. $\theta' = B_1$, a constant. $\log E_0' = H'$, a constant

Note that $\log E_0'$ is here generally negative since E_0' is less than 1 lux and $\log 1 = 0$.

Determination of constants p and k.

The diameter of optical aperture, p , can be measured by a micrometer having a scale in the eyepiece of the telescope. The constant k can be rapidly measured by alternately observing, with one eye, a white screen as seen through the telescope and through a photometer with adjustable absorbing prisms which can be regulated so as to get equality of brightness.

IMPORTANCE OF PART PLAYED BY ACUTENESS OF VISION.

It has been explained above that the coefficient used to allow for acuteness of vision has the value $a' = a.10^{-\frac{1}{\theta B b}}$; if we take the data given by Koenig we

¹ The maximum acuteness for some persons may, according to Koenig, reach 1.5—1.7 of the normal.

find for an object giving an acuity 0.20 at 1 kilometre, $a' = \frac{a}{10^{0.41}}$ or $a'' = \frac{a}{10^{4.1}}$ according as we are dealing with cone- or rod-vision. This figure is evidently of supreme importance in determining acuteness of vision.

Take for example an object 7 m. 25 in length (e.g., house or boat) seen at a distance of 1 kilometre ($x=x_1$) with an acuteness of vision $V = \frac{1.45}{7.25} = 0.20$ of the normal, and by the aid of a searchlight whose intensity just suffices for visibility. In order that the same object may be seen with equal clearness (again with the naked eye) at a distance ($x=x_1$) five times as great, it will be necessary (assuming a value for a' corresponding with cone-vision) to obtain an apparent illumination 100 times as great; that is to say we require 100 times the candle-power of the source; at the same time the increased distance will involve a multiplying factor of $5^2=25$ and the atmosphere absorption will require yet another increase of $\frac{a^{10}}{a^2}=a^8$. For example, if $a=0.70$ $a^8=0.06$.

Thus the total candle-power required will have to be :— $\frac{100 \times 25}{0.06} = 42,000$ times as great as before.

This example shows that the visibility of the object decreases very rapidly, and much more quickly than the range of a searchlight, in which the factor $\frac{a^x}{x^2}$ occurs, or than the range accorded to Nerz's formula $\frac{a^{2x}}{x^4}$.

APPLICATION TO HEADLIGHTS OF LOCOMOTIVES.

One of the objects of the headlights on a locomotive is to enable the engine driver to perceive an obstacle, such as a man crossing the line, in time to pull up.

Some important tests have been recently carried out on this subject by several railway companies in the United States, notably by the American Railroad

Master Engineers' Association¹ and the results have been expressed in the simple parabolic formula: $I = Ax^n$. Here, A and n are constants whose value depends on the nature of the light employed, and the colour of the clothes of a man of average height assumed crossing the line in the path of the rays from the headlight; n varies from 2 m. 60 to 4 m.

It is evident from the preceding considerations that formulæ of this character cannot represent the conditions exactly, and should be replaced by a formula of the type (10):— $I = \frac{Ax^2}{(a'')^x}$, or of the

type (6 bis), the constants being deduced on the assumption that we have to deal with rod-vision.

Analogous formulæ could be established for the observation of objects on the road in front of an automobile and in this case the constant H would have much smaller values owing to the ready manner in which objects can be distinguished against the illuminated road as a background.

INFLUENCE OF THE NATURE OF THE LIGHT AND THE COLOUR OF OBSERVED OBJECTS.

Visibility depends very much on colour. For example, in the experience of the American Commission, quoted above, it was found that a man dressed in light grey or even in blue can be seen at a distance very much greater than a man dressed in black; for example with a candle-power of 8,000 the relative figures for the range are respectively 350, 180 and 125 metres. This result shows that

¹ Special Report, Headlight Committee (A.R.M.M.A., June, 1914). See also J. L. Minick, on Locomotive Headlights (Trans. Illuminating Engineering Society, 1914, No. 9, pages 909-925).

According to these results the range of a headlight is actually insufficient to enable the driver to pull up in time to escape an observed obstacle; especially if one takes account of the inevitable loss of time in the period of physiological reflex between the instant that the object is observed, and the moment when the brake is applied. This period may be also increased by *visual inertia*, of the type studied by A. Broca and Sulzer (Journ. de Physiologie and Pathologie, No. 4, July, 1903).

at night illuminated objects detach themselves appreciably from a black background, whereas during the day the neighbouring area is always more or less brightly illuminated. If one applies these considerations to the uniforms of infantrymen, one recognises that the grey-blue uniforms which give a minimum of visibility by day are, on the other hand, less favourable in this respect by night than a dark blue. The disadvantage of light blue is especially marked in the case of objects illuminated by the electric arc, the rays from which are richer in the blue and violet than other artificial illuminants.

On the other hand a monochromatic source of light would give rise to an acuity greatly superior to that attained from mixtures of various colours, such as exist in ordinary polychromatic sources—on account of the effect of chromatic

aberration in the eye.¹ From this standpoint projectors having gilded mirrors, which retain the most valuable rays but suppress those considerably in the highly refracted region of the spectrum, are favourable to visibility. In order to accentuate the contrast-effect it is desirable that the direction of view of the observer should be inclined at as great as possible an angle to that of the beam of the searchlight.

This condition is also desirable with a view to diminishing lateral illumination of the retina which has an unfavourable effect on vision. Moreover the use of the less refrangible rays is also beneficial in reducing the quantity of light scattered by the minute drops of water or particles of dust in the air, forming a luminous haze and interfering with clear vision; this is proportional to the fourth power of the wave-length.

¹ Cf. M. Luckiesh, *Electrical World*, 19th August, and 1911, p. 450, 18th November, 1911, p. 1252. J. S. Dow, *Electrical World*, 14th October, 1911, p. 955. Louis Bell, *Electrical World*, 9th September, 1911, p. 637.

SEARCHLIGHTS ;

Some remarks on the more usual electrical systems of operation.

By J. F. CROWLEY.

I WAS much interested in the discussion that took place before the Society on "Searchlights," and can support Mrs. Ayrton's remarks regarding the importance of the electrical apparatus in the production of a steady light for searchlight work.

For searchlight arcs, direct current is almost invariably used, being both more efficient and satisfactory for this purpose than alternating current.

The following are the direct current systems more generally employed :—

(a) The feeding of one or more lamps from ordinary supply mains, a stability resistance being used for each arc.

(b) A separate generator for each arc, with or without a stability resistance.

(c) A separate converter for each arc, used with or without a stability resistance, connected to the mains of the supply system, and designed either for :—

(1) Complete transformation, or

(2) Partial transformation.

For work where heavy currents are dealt with, system (a) is very uneconomical, while, in addition, the shape of the electrical characteristic is a straight line, the inclination of which depends upon the voltage of the supply. Where a steep characteristic is required, therefore, the supply voltage must be high, and the energy wasted in the system will be considerable.

The arrangement in case (b) is more particularly used for isolated searchlights, and for those which are required to be portable, but not frequently on board ship where many searchlights are as a rule installed.

Case (c) is the more general one for searchlights for ship use, as the ring main system is usually of high voltage and requires to be reduced for use on the lamp.

Some years ago I carried out a number of experiments with a view to designing a searchlight generator of the converter type, that would give the best results. Generally speaking, such generators and converters should possess:—

(a) Extreme lightness and portability, which necessitates the utilisation of steel parts and of aluminium where this metal can be employed.

(b) Compactness, particularly where the apparatus is to be used on ship board, in which case it is usual to employ vertical spindle machines, which generally permit of the best utilisation of the space available.

(c) An electrical characteristic which will give the best results on the lamp.

Points (a) and (b) are purely matters of design, and do not affect the light obtained from the lamp; (c) is, however, of the utmost importance if a stable arc is to be maintained.

The shunt feed series strike lamp is one in common use, and to enable what follows to be understood, it may be well to briefly describe its action. On closing the lamp circuit, the carbons may either be in contact, or, as is sometimes the case, apart.

If they are in contact, a heavy short circuit current will pass through them, and, therefore, through the series striking coils, on which the carbons will be immediately pulled apart, and the arc "struck." Should the carbons be already apart, however, the full open circuit voltage of the generating system will be thrown across the terminals of the shunt feed coil, which will cause the carbons to gradually feed until they come into contact, on which a current will flow of sufficient value to operate the series coils and thus cause the arc to "strike."

Once the arc is "struck," the duty of the series coils is ended, and the shunt coil has to maintain the arc by feeding forward the carbons as they burn away. This it does in the following manner. As the carbons burn, the resistance of the arc increases, the lamp current falls, and the supply system is so arranged that on the current falling below the value for which the apparatus is adjusted, the voltage rises sufficiently to operate the shunt coil and bring the carbons to the correct distance once more. On the

other hand, when the current reaches a high value, as, for instance, when the carbons come together, the voltage falls, and the shunt coil ceases to feed. It is on the capability of the system to give on a slight fall in current a rapid and sufficient rise in voltage to overcome any changes in the arc due to irregular burning and to fulfil the conditions of feed just outlined, that the whole question of stable burning of the arc depends, so far, at any rate, as this is affected by electrical considerations. Some misunderstanding would seem to exist on this point, since stress was laid in the recent discussion on the necessity for having:—

(a) A high voltage of supply, and

(b) A large resistance in series with the arc.

What should actually be specified is that the load characteristic of the generating apparatus should be such as to give a steep curve over the working range of the lamp, *without* a stability resistance, which is inefficient, and *without* requiring a high open circuit voltage, which, among other disadvantages, may produce sparking at the shunt feed contacts. A high current value is desirable on short circuit when the carbons come together.

Without entering into detail, it may be said that these are the essential requirements of the electrical system for searchlight work. When a generator or converter gives a satisfactory characteristic, no stability resistance of any kind should be required, provided the resistance of the leads is, as is usually the case, of such a value as to prevent trouble arising from short-circuit effects. Careful adjustment of the striking and feeding devices of the lamp when operating with the generator is necessary if the best results are to be obtained. The whole system is very sensitive, and slight want of adjustment may produce unstable burning.

For lamps of the usual type with horizontal carbons, a magnet which has for a magnetising coil the single turn consisting of the carbons and supports, through which the lamp current flows, is used to maintain the central burning of the arc, which has otherwise a tendency to burn upwards, due to the air draught produced by the flow of the heated air in the lamp through the openings at the top of the enclosing case.

THE RATING AND MARKING OF LAMPS AND THE BEST METHODS OF SPECIFYING THEIR ILLUMINATING VALUE.

Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 8 p.m., on Tuesday, March 16th, 1915.

A MEETING of the Society was held as stated above, Mr. Leon Gaster being in the chair.

The minutes of the last meeting having been taken as read, the Hon. Assistant Secretary read out the names of the applicants for membership in the usual way.

The CHAIRMAN then called upon Mr. F. W. WILLCOX to read his contribution (see p. 163), and subsequently Mr. C. H. WORDINGHAM opened the discussion in which the following also took part:—

Mr. C. C. PATERSON, Prof. J. T. MORRIS, Mr. J. MACINTYRE, Mr. J. T. FLETCHER, Mr. T. E. RITCHIE, Mr. J. G. CLARK, Mr. M. FOULDS, Mr. LE MARECHAL, Mr. J. S. DOW, Mr. F. S. TILLEY, Mr. STROUD and Mr. BUSSEL.

Written contributions to the discussion by Professor SILVANUS P. THOMPSON, Mr. F. W. GOODENOUGH, Mr. E. ALLEN, Mr. HAYDN T. HARRISON, Mr. W. J. A. BUTTERFIELD, and Mr. GEO. KEITH were also read by the ASST. HON. SECRETARY

The CHAIRMAN called for a vote of thanks to Mr. WILLCOX for his paper, and to Mr. WORDINGHAM for coming to open the discussion. Finally it was announced that the **next meeting** would take place on **April 27th**, when a discussion on "**Visibility ; its practical aspects**" would be initiated by Mr. C. C. PATERSON and Mr. B. P. DUDDING.

NEW MEMBERS.

At the meeting of the Society on March 16th the names of the following applicants for membership were read out:—

Cheetham, A. S.	Engineer, Sir W. Armstrong, Whitworth & Co., Ltd., Elswick Works, NEWCASTLE-ON-TYNE (2).
Evered, G. J.	Managing Director of Messrs. Evered & Co., Ltd., Surrey Works, SMETHWICK (2).
Gilbert, Walter	The Bromsgrove Guild, BROMSGROVE, Worcester-shire (2).
Johnson, J. H. <i>M.I.E.E.</i>	Electrical Engineer, Messrs. Crompton & Co., CHELMSFORD (2).
Staniforth, H.	Gas Engineer, 88, North Side, Clapham Common, LONDON, S.W. (2).
Tilley, F. S.	Managing Director, The Tilley High Pressure Gas Syndicate, 53, Kingsland Road, N.E. (2).

In addition the names of members announced at the previous meeting on February 16th* were read out again and these gentlemen were formally declared members of the Society.

* *Illum. Eng.*, Lond., March, 1914, p. 101.

THE RATING AND MARKING OF LAMPS AND THE BEST METHODS OF SPECIFYING THEIR ILLUMINATING VALUE.

In view of the great variety of lamps and reflectors now available, and the wide difference in the distribution of light yielded by them, the question of the methods to be adopted for the rating and marking of lamps, mantles and lighting units has become a very important one.

Previous to the discussion on this subject at the last meeting of the Society on March 16th, the following list of points was prepared for consideration :—

(1) The rating of electric incandescent lamps in watts *versus* candle-power.

(2) The discussion of the following resolution passed at a recent meeting of the Committee on Nomenclature and Standards of the Illuminating Engineering Society in the United States :—

(A) That the output of all illuminants should be expressed in lumens.*

(B) That illuminants should be rated upon a lumen basis instead of a candle-power basis.

(C) That the specific output of electric lamps should be stated in lumens per watt, and the specific output of illuminants dependent upon combustion in lumens per British thermal unit per hour.

(3) What additional particulars are necessary to be furnished to illuminating engineers for use in planning lighting installations ? (viz., polar curves of light distribution of the bare lamp, or of the unit composed of lamp and reflector, &c.). Should the candle-power of lamps and lighting units be stated in terms of mean spherical candle-power, mean lower hemispherical candle-power or candle-power in a particular direction ; or the ratio between maximum and mean spherical candle-power of the lamp given ?

(4) The desirability of adopting, in all literature on illumination recognised symbols for the candle-power as follows :—

I_o = mean spherical candle-power.

I_u = mean upper hemispherical candle-power.

I_l = mean lower hemispherical candle-power.

I_α = candle-power at an angle α with the vertical.

(5) The practicability, in specifying interior lighting, of requiring a certain illumination on the working plane in foot-candles, as compared with furnishing a certain wattage, consumption of gas, or candle-power per square foot of floor area.

* A Lumen may be defined as the flux of light required to produce an illumination of one foot-candle on an area of one square foot.

THE PRACTICAL RATING OF ELECTRIC INCANDESCENT LAMPS.

BY FRANCIS W. WILLCOX.

Contribution to a discussion at the meeting of the Society held at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.), at 8 p.m., on Tuesday, March 16th, 1915.

At the meeting of this Society on May 21st, 1914, Mr. A. P. Trotter, in his paper on "The Nomenclature and Definition of Photometric Units," put forward a very able plea in support of the candle-power as the fundamental unit.

In the discussion on this paper, Mr. C. C. Paterson defended the case for the luminous flux and showed the deficiencies of the simple candle-power as a unit for use in general lighting problems.

I am not concerned here with the theoretical aspects of this subject, because these have already been fully and ably covered at the meeting referred to. I only refer to this discussion in order to point out the very clear evidence it presents that candle-power as an all-round lighting unit has been found wanting. It is being displaced as a practical rating unit, largely as a result of its own deficiencies.

The primal reason for this is found in the fact that candle-power is a somewhat loose term, readily abused, and is being used in a dual sense. As Mr. Paterson pointed out in the above discussion, candle-power is used as a conception of luminous intensity or power and also to express the numerical value of a source of light. Furthermore, candle-power being a derived unit and not a fundamental one, its insufficiency became evident when an attempt was made to establish a complete system of lighting units and co-ordinate these with the actual expenditure of power required to produce the light.

The writer well remembers the time in the United States, in the early days of the metal filament lamp, when the rating of electric incandescent lamps was changed to total watts as a practical

size rating in place of candle-power (which had previously been used with carbon filament lamps). This change did not arise out of any theoretical considerations, but purely out of a practical one, viz., the desire to obviate the misleading values it was possible to assign to electric lamps under a rating by candle-power. Serious abuses had arisen in the cases of special lamps, such as the "Nernst" lamps, which, by virtue of their special construction (the frame of the lamp acting as a reflector), were able to give a multiplied value of apparent candle-power beneath the lamps. These lamps were accordingly rated on the candle-power value of this downward maximum beam of light.

The glow lamp manufacturers were compelled to meet such fictitious ratings by adopting similar tactics—silvering the top portion of their lamp bulbs and employing a special horizontally displayed filament to obtain downward light concentration and a maximum apparent candle-power value. This led to considerable confusion and uncertainty in ratings and values. To overcome these abuses, the electric glow lamp industry fell back on the wattage of the lamp and began rating lamps in total watts. This provided a simple, definite rating that could not be manipulated as candle-power had been.

In this matter the incandescent lamp simply repeated the history of the arc lamp which, on the candle-power basis, had been rated at very high values (the value of the maximum ray), resulting in the dropping of candle-power as a unit of rating for the arc lamp and the adoption of watts or amperes instead.

The rating of incandescent lamps in total watts, therefore, in place of candle-

power, forced itself into practical use purely as a defence against abuses which had grown up with the unit of candle-power. This change met with a great deal of opposition at the time, as engineers and users of electric light had become accustomed to the term "candle-power" and believed, or thought they believed, that no other term could take its place. Nevertheless, the practical reasons which prompted the adoption of the total wattage rating prevailed over all opposition and forced its acceptance into general practice. Curiously enough, this change which took place in the States appears also to have been independently adopted in Great Britain, and has been employed without any serious objection or any practical difficulty for the past four or five years.

It has been found that it is just as easy to form an idea of the light a lamp gives when it is called a 40-watt lamp as it was when it was called a 32-c.p. lamp. A lamp by any other unit will shine as brightly. In fact, as far as the public is concerned, a simple indicating number without any terms will suffice, after an experience, to determine what is required. Most people don't know and don't care what 32 c.p. really is—they get an idea of the effect by trial and use, and that is all they want.

The subsequent developments in incandescent electric lamps, the multiplication of shapes of filament and the considerable advances in efficiency realised in the past year or two, have all accentuated the value of the total watts rating as a practical size rating and thus confirmed it more fully than ever.

Now I would like to point out that there has been no complete abandonment of the candle-power unit. To express the total luminous power or flux of light given by a lamp, we employ such values in one form or another as the necessary means of expressing the efficiency of a lamp. This efficiency is given, of course, by the ratio of the luminous output to the energy input or total watts consumed by the lamp. As a practical size rating, however, for the incandescent electric lamp, the total watts has been adopted by force of the conditions mentioned above and for the reasons detailed hereafter. The watts remain fixed and the candle-

power values change. The result of this is to give increased values of candle-power with every advance in efficiency.

Now this is the desirable plan (as compared to the alternative, *i.e.*, a fixed candle-power with changing total watts), as we shall see when we review the summarised reasons for the watt rating. The general trend in practice is to higher lighting values, *i.e.*, to an advance in candle-power which the rating on a fixed watt basis insures.

The adoption of the watt rating has resulted in the establishment of a line of fixed standard watt values, 10, 15, 20, 30, 40, 60, 80, 100, 200, &c., watts for metal filament glow lamps, which all manufacturers have adopted. While candle-power values will still be used as needed, they will be derived values obtained by dividing the watt rating by the efficiency.

It can readily be understood, for example, that it is very important to the largest class of lamp-users—electric supply station customers—to have the total watts of the lamps stated and fixed, as light is purchased on the basis of the watts consumed. With advances in efficiency, however, this would not be possible if we had to provide a fixed line of candle-power sizes, as with every advance in efficiency the total watts would have to change and there would be continual shifting of the watt consumptions of the various lamp sizes, which would complicate the situation for supply stations and their customers. In the old carbon days, when lamps were rated in candle-power, the efficiencies of lamps were practically stationary and this complication did not arise.

With the rating in total watts, it is not intended to deny any user the privilege of having the candle-power (or other luminous unit value) of the lamp where it is necessary to have it; but such candle-power values will not be fixed values, as this would prevent the very desirable condition of a fixed total wattage which is found to be such an eminently practical basis for central station consumers.

With this general introductory explanation, we can now briefly review the summarised reasons for the adoption of total watts as the basis for the rating of metal filament lamps.

TABLE I.

STANDARD SIZES OF TUNGSTEN INCANDESCENT LAMPS. FIXED TOTAL WATT RATING AND DIVIDED CANDLE-POWER VALUES CORRESPONDING.

Voltage.	Size in Fixed Total Watts Rating.	Candle-Power as derived at present Efficiencies.	Candle-power as it would be with about a 10% advance in Efficiencies.
100 to 130	10	8	8
	15	12	12
	20	16	16.7
	30	25	26
	40	33	35
	60	50	54.5
	80	67	73
	100	90	100
	150	150	150
	200	200	200
	400	400	400
200 to 260	15	10	10
	20	14	15
	30	22	23
	40	30	33
	60	48	52
	80	64	70
	100	80	91
	150	120	136
	200	160	182
	400	320	400

TABLE II.

LAMPS WITH FIXED C.P. SIZES SHOWING THE CHANGE REQUIRED IN TOTAL WATTS WHEN EFFICIENCIES ARE ADVANCED.

Sample line of sizes in Fixed Candle-Powers.	Derived Total Watts Resulting at present Efficiencies.	Derived Total Watts on scale of about 20% advance in Efficiencies.
15	20	16
20	25	20
25	30	25
30	40	30
40	50	40
50	60	50
60	75	60

The last column above, it will be seen, simply repeats the total watt values in the second column. The same total watt values are shown advanced one step in the candle-power line. (See par. No. 8 of summarised advantages of total watt rating, p. 166.)

Practical Reasons for adopting Total Watts as a size rating for Electric Glow Lamps.

"(1) Total watts is a more positive rating, as watts are definite, unvarying and a physical quantity, whilst candle-power is more or less indefinite and is physiological quantity. We have the difference between the Hefner candle-power standard and the English standard, between the mean spherical, the mean hemispherical and the mean horizontal, &c., as well as the candle-power given with different forms of reflectors. We have no such differences with watts. A watt is a watt whether the candle-power is measured as spherical, horizontal, or otherwise, or whether measured in Germany or in England.

"(2) The correct determination of the candle-power of a lamp requires some equipment and trouble in any case. It is hardly a practical matter for the generality of users, including many engineers, to determine the candle-power of lamps, and the history of the lamp business proves this conclusively. We can go back to the old carbon lamp. Anybody in the lamp business knew how easy it was to fool the public in respect of candle-power. Lamps might be called 16 candle-power lamps when they were only 12 or 13, and then be passed off as having an efficiency of 4 watts per candle when they were actually 5. The difference between 4 and 5 watts per candle in efficiency makes a great difference in life and candle-power performance, all as a result of an underrating of two or three candle-power which the eye does not detect, and which customers do not measure because they have not the equipment and experience.

"(3) The wattage of lamps is very easily and definitely obtained by a simple wattmeter reading. Lamp values therefore can be more easily checked in watts.

"(4) With total watts as the rating we have a more even fixed value for the period of the lamp's burning life. The total watts of the lamp change very little, not over 5 per cent., in the same period in which the candle-power declines some 20 per cent. In the matter of time element therefore the total watt rating is a more definite and unvarying rating than the candle-power. The candle-power rating to be exact must be described as the 'initial' candle-power, or the value at start of a lamp's life; or the 'average' candle-power, or the average value during the period of the lamp's life; or 'final candle-power,' or value at the end of the lamp's life.

"(5) As light is sold on the wattage basis, the total watts consumed by the lamp is the most important thing to know. The majority of the lamps are employed on the circuits of the central supply stations where a definite value in watts is required for both the station engineer and the consumer for estimating or checking the cost of the service. In all other cases, such as private plants or Government installations, the total watts value is also an important matter for apportioning the costs, the losses in lines, and the capacity of supply apparatus.

"(6) Practical lighting work and illumination determinations are to-day almost universally

calculated upon total watts as a basis. This is the standard practice of most of the engineers and companies doing this work in England and America. The total watts form a much more convenient and practical unit for estimating lighting work, and simplify the determination generally. If we wanted to determine the values for lighting a room, we should take the square feet of the room, and multiply it by a constant taken from the illumination value table and representing the watts per sq. ft. required to give the desired illumination, the result being a certain total watts indicating the lamps required. In this way we determine the actual requirements without reference to candle-power.

"(7) The adoption of total watts as a primary rating for lamps is the natural outcome of practical experience. It repeats the same evolution that took place in arc lamps, for which the candle-power rating was abandoned years ago in favour of watts. Manufacturers were rating their arc lamps in thousands of candle-power, whilst the actual candle-power of a lamp on the mean spherical basis was very much less. The practice was to take the value of the maximum ray, and it was finally decided to drop candle-power rating because of such abuse and overrating.

"(8) With candle-power as the fixed primary rating the total watts will have to be varied from time to time as improvements in efficiency come along, and these changes would cause confusion and introduce complexity in the business of lamp manufacturers and also for the consumer and supply engineer. This would have been particularly the case in the last two years when the efficiencies of incandescent Tungsten lamps have advanced from 1.25 to 1.0 watts per candle. If we had started two years ago with the scale of wattages we have to-day, and instead of carrying a fixed wattage had held to a fixed candle-power, and lowered the wattage as we went up in efficiency, we should have gone down so that we would practically have the same watt scale over again on the lower basis—lamps would simply have been shifted 20 per cent. in candle-power. (See Table II.) In the meantime we should have had confusion, and we might as well have held to the fixed watt values in the first place and increased the candle-power, instead of going through the scale of evolution for two or three years and finally arriving at the same watt values in the end. We have more recently had the introduction of half-watt lamps with previous efficiencies doubled. These lamps, and the improvements in lamp efficiencies to come, constitute still greater changes than we have had in the past. These changes will emphasise this point even more in the future than they have in the past.

"(9) The total watts is the unit generally employed for electrical work and the one most widely dealt with and known to the industry. We have watts as a basis, for example, in practically all electrical apparatus, transformers, meters, motors—(H.P., which is of the same character as watts)—and heating apparatus. The energy these devices consume is the basis of the practical rating.

Various Forms of Lamp Filaments

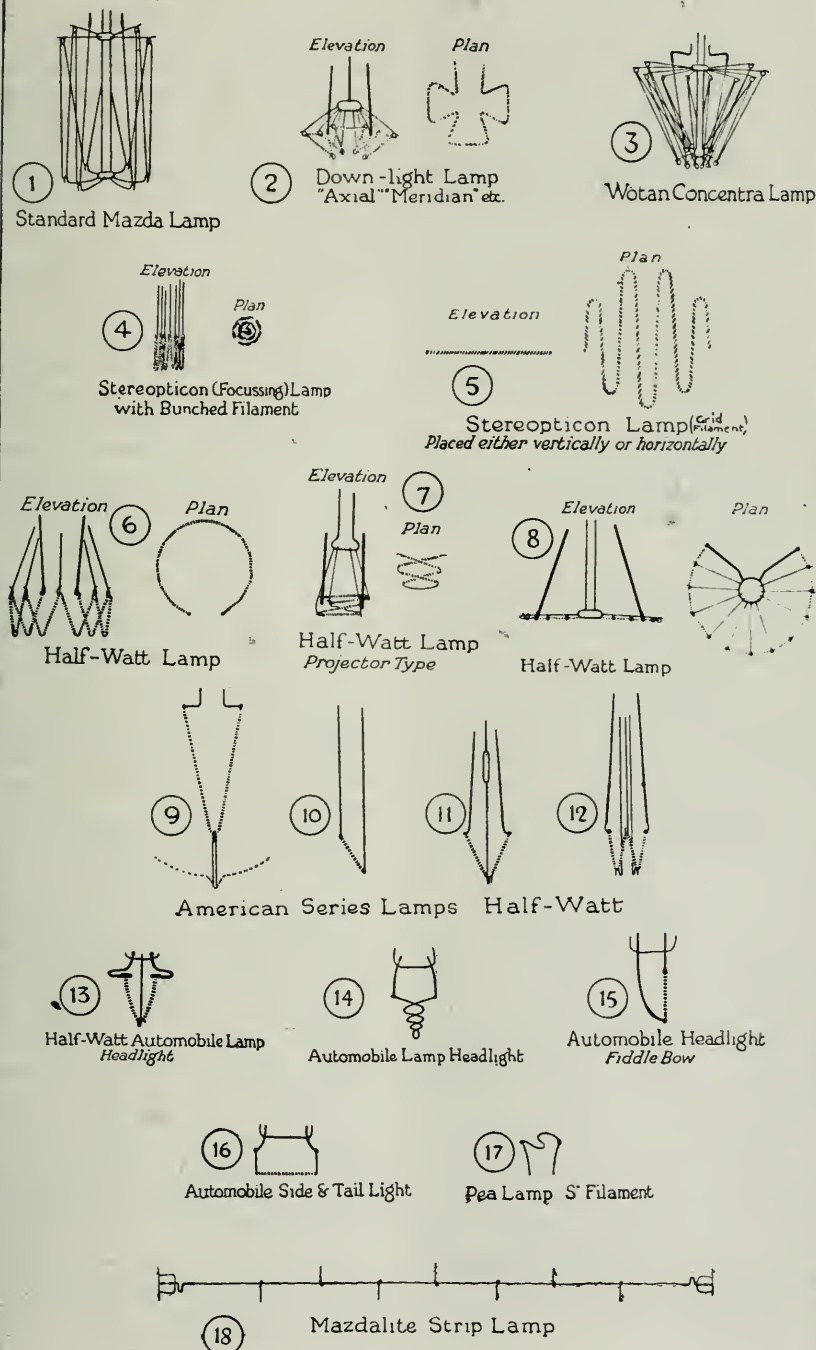


FIG. 1.—Various forms of Lamp Filaments.
(All forms, except 1 and 14, are made with helix-wound wire.)

"(10) The primary rating in watts simplifies matters. It is practicable to get along with total watts for lamp rating without candle-power, but if candle-power be employed as a primary rating you must also use total watts.

"(11) With fixed candle-power rating it is necessary, by reason of the lower efficiency of 200—250 volt lamps, to have two sets of watts values, one set for 100—130 volts, and another, a higher set, for 200 volts. This would undoubtedly call attention to the lower efficiency of 200 volt as compared with 100 volt systems. I think you would have serious complaints from central station engineers of the 200 volt systems if they had to employ a 25 or 35 watt lamp whilst a neighbouring station supplying 100 volts were able to offer a 20 or 30 watt lamp.

"(12) The fact that watts have been used as a primary rating by 80 per cent. of the manufacturers in England, ever since the Tungsten lamp was introduced, some four or five years ago, proves that the use of total watts rating is not a new untried thing; it is the standard practice in the United States, and in Canada as well as in Great Britain."

These, then, are the reasons for the watt rating of electric glow lamps which have prevailed, and which are, it will be noted, nearly all purely practical reasons derived from experience.

It has always seemed to the writer that the power consumed by the illuminant is a very natural unit to have and to work upon, as it only needs to be coupled with the efficiency value to give immediately the actual luminous output. As engineers we are all concerned chiefly with the question of power expenditure, and, in fact, it is hardly possible to consider the central element of engineering, *i.e.*, efficiency, without first considering power or energy. As the *Lighting Journal*, U.S.A., states in a recent editorial:—"There is no excuse for the engineer whose business it is to handle power balking at the thought of light as power. The Committee on Nomenclature and Standards of the American Illuminating Engineering Society defines the light or luminous flux of a lamp as 'radiant power evaluated according to its capacity to produce the sensation of light.' Radiant power is expressed in watts which should be sufficiently comprehensible by the engineer, and the evaluating factor (efficiency) is a simple number. Consequently light flux can be described and, what is more, measured as watts, given the proper evaluating or efficiency factors."

It is not necessary to measure the candle-power of lamps to determine the efficiency, as this can be accurately determined by temperature by colour match.* In fact, this method is of particular value when dealing with lamps of great brilliancy and high temperature such as the latest half-watt electric lamps. Such lamps are rated without candle-power measurements. The efficiency is determined by a colour match with a standard lamp of determined efficiency, and this and the total watts determines the candle-power.

THE DESIRABLE UNIT FOR EXPRESSING LUMINOUS VALUES.

As I have stated in the first part of this paper the industry will continue to employ candle-power or some unit to state the luminous value of a lamp where it is required, as such values are necessary to express the efficiency of a lamp. It will be pertinent, therefore, to consider what is the most desirable unit for expressing the luminous value.

Shall it be the candle-power, or the lumen? Without going over the theoretical points for and against these units, so well covered in Mr. Trotter's paper and the discussion at the meeting of this Society on May 21st, 1914, I should like to give some practical reasons which appear to me to bear on the question as far as electric glow lamps are concerned.

The same reasons stated in the first part of this paper, which led to the substitution of candle-power by total watts as the practical size rating of electric lamps, will, in my opinion, lead (and are already leading) to the adoption of the lumen in place of candle-power where it is necessary to express the luminous value.

The fundamental requirement is a *definite* unit which shall always mean one definite thing. This the lumen is and the candle-power is not. We have already indicated the many variations of candle-power there are in use, the mean horizontal, mean spherical,

* See paper before The Physical Society of London, by C. C. Paterson and B. P. Dudding, on "The Estimation of High Temperatures by the Method of Colour Identity," March, 1915.

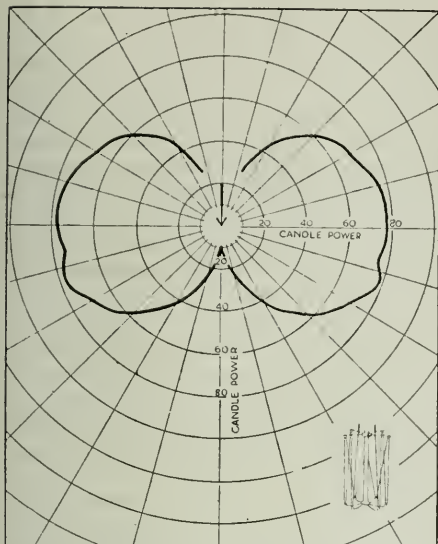


FIG. 2.—100-watt clear Standard Tungsten Lamp. Light distribution of bare lamp, in vertical plane.

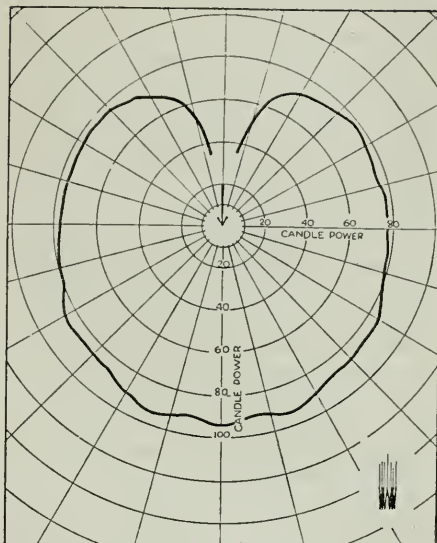


FIG. 4.—100-watt Stereopticon Lamp. Light distribution of bare lamp, in vertical plane.

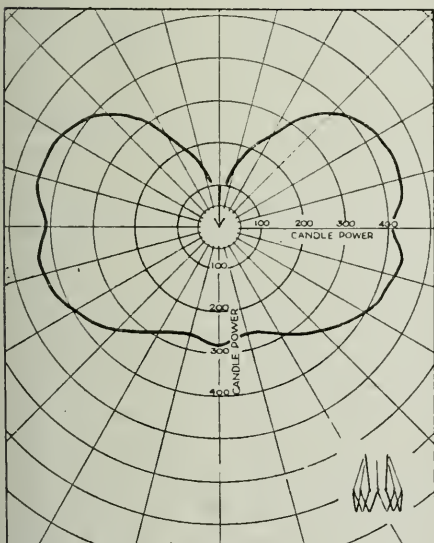


FIG. 3.—300-watt Half-watt Lamp. Light distribution of bare lamp, in vertical plane.

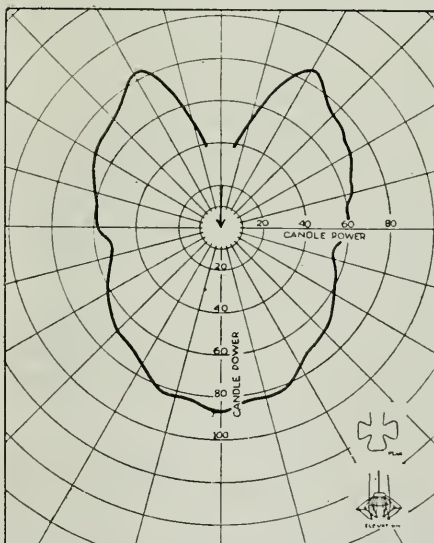


FIG. 5.—100-watt Spiralised Filament Lamp. Light distribution of bare lamp, in vertical plane.

Distribution of Light from typical Metal Filament Lamps.

hemispherical upper, and hemispherical lower, and the candle-power values in different directions, &c. Such complications do not arise with the lumen. In determining or expressing efficiency, for example, the usual term "watts per candle" raises a query at once, as to what variety of candle is meant—whereas watts per lumen or lumens per watt is wholly definite.

Then, again, the desirable unit should not permit of manipulation or alteration of apparent value by reason of change in shape of the luminous body (lamp filament) or through the use of any external or accessory devices, such as reflectors. Now this has been found in experience to be the chief defect of candle-power as a unit. Numerous examples can be given. Take the filament of a lamp, giving 16 (horizontal) candles in the ordinary lamp and shape it in a horizontal grid form and place it in an onion shape bulb and note the large increase in candle-power when measured vertically. Frost the glass of the upper part of the bulb and note the further increase in candle-power. Silver this same upper surface and note the still further increased value of candle-power. We have not changed the actual luminous output of the filament in the least. It is the same section and length of filament, and yet we have so manipulated it and changed the upper surface of the bulb as to give apparently very much greater candle-power values, as the term "candle-power" is employed, than we obtained from the same length and section of filament in the ordinary lamp.

Again, take the case of the double cap tubular lamp with straight line filament backed by reflectors. Here the flux of light is all in a direction normal to the length—with no "end-on" candle-power practically at all.

This latitude in expressing candle-power permits and encourages misrepresentation in lamps. The writer noted a case of it this past week in a so-called half-watt lamp of hitherto unknown make. This lamp was found not to be a gas-filled lamp at all—only an ordinary vacuum lamp—with a horizontal filament of spiralsised wire placed in a round bulb with its upper half opal coated. The effect of this combination made the lamp look brilliant and gave an increased

downward candle-power value, sufficient to justify calling it a half-watt lamp.

Here the deception can be detected by temperature measurements, through a colour match with a bona-fide half-watt lamp.

The variations in candle-power values in different directions with different kinds and shapes of reflectors are an old story. The same light flux (lumens) is made to yield now to 50, now 100, here 500 and there 1000 candle-power values. Such a condition has its extreme example in the well-known case of the searchlight and even Mr. Trotter, I believe, has to take refuge in the lumen in such a case.

Now the lumen cannot be manipulated. The luminous output of a lamp as expressed in lumens remains the same whatever the shape of the filament and no matter what variations of external arrangements or what accessories (reflectors, &c.) may be employed with it (excepting of course the absorption losses in the accessories).

The importance of this point will be appreciated when we consider the large variety of filament shapes employed in modern lamps and the exceeding difficulty of trying to assign candle-power values to many of these lamps. Let us examine some of these shapes and their light distributions, as shown in the plates herewith (Figs. 2, 3, 4 and 5). Surely the use of the lumen recommends itself when we consider such cases.

The candle-power suffers from the infirmity of being materially different according to the direction at which it is measured. Practically a unit of candle-power should have the same value whether measured horizontally, vertically, or at any angle. Actually it does not, as we readily find out when we consider the spherical surface surrounding the lamp. This is one of the things that will always be more or less mysterious to the layman and that assists in deception and misleading information. Even those who know the subject fully, find it very difficult to judge properly between the merits of different light distributions in the various zones.

This point is exemplified in the following geometrical diagram (see Fig. 6), where the same total flux of light is given in different light distribution circles.

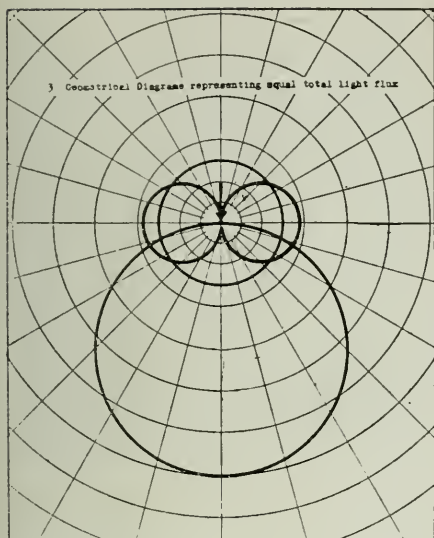


FIG. 6.—Ideal curves, showing same total light flux in various forms of light distribution. (Note the apparent large increase in lower circle as compared with the other curves.)

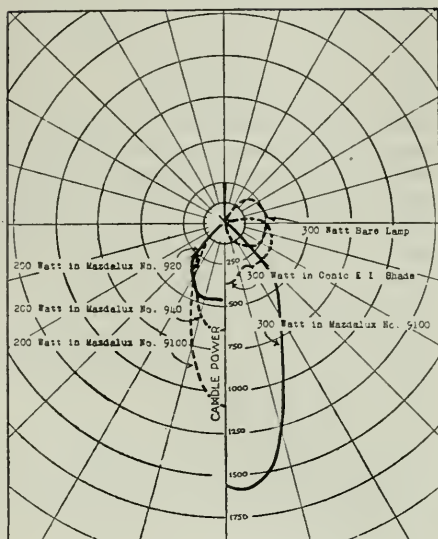


FIG. 8.—Variation in apparent candle-power values of a 300-watt lamp through use of different reflectors.

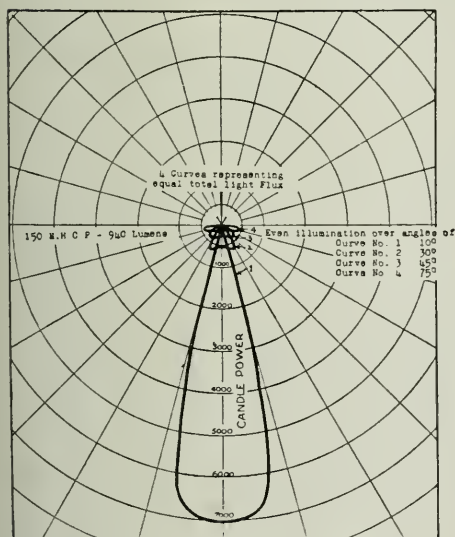


FIG. 7.—Diagram showing how, in an extreme case, same total light flux may be distributed so as to show very misleading values of apparent candle-power. Notwithstanding its far greater area, the flux of light represented by the large curve (1) is the same as that represented by the three very small ones (2, 3, and 4).

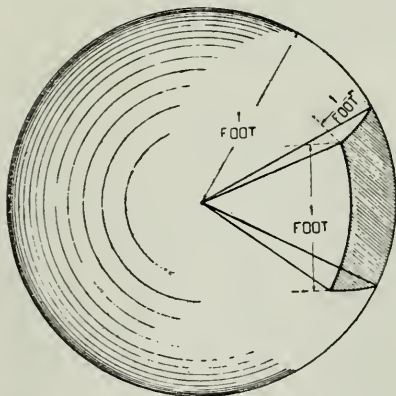


FIG. 9.—Diagram illustrating the nature of the lumen.

The same point is shown in Figs. 7 and 8, where the same total light flux (lumens) is altered by the use of reflectors to give very misleading apparent candle-power values. These diagrams are striking illustrations of the confusion of values under a candle-power rating. This latter point and the preceding point regarding the manipulation of unit values are further emphasised when we consider the great variety of distributions obtainable with reflectors and enclosing glassware. The design of modern reflectors has been carried to a point of great elaboration.

(Here slides were shown illustrating the greater variety in the light distribution from various reflectors and bowls of modern scientific design.)

Modern lighting methods, such as indirect lighting, distribute light flux in the upper hemisphere on to the ceiling for re-distribution to the area beneath—

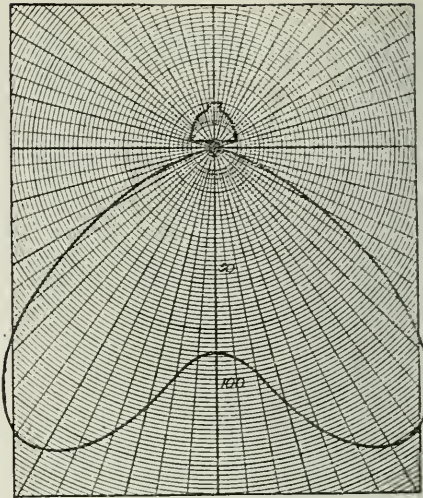


FIG. 10.—Distribution Curve of typical reflector.

TABLE III.

CORRESPONDING RECORD SHEET OF REFLECTOR (SEE FIG. 10), SHOWING LUMEN VALUES IN THE VARIOUS ZONES.

Reflector X-RAY No. 555.
Lamp Mazda 5-21-E clear Watts 60-0.
Calculated by J. A. H.

Reflector No. 555.
Holder 2½ in. form o.
Volts 110-0.
Test No. CW-9.

LIGHT FLUX DELIVERED.

Zone.	Mid-Zone.		Lumen Constant.	Lumens.	Zone.	Lumens.	Per Cent. of Bare Lamp Flux.
	Angle.	C. P.					
		per cent.	per cent.	per cent.		per cent.	per cent.
0—10°	5°	92.6	.0954	8.8	0—10°	8.8	1.7
10°—20°	15°	117.0	.2834	33.1	0—20°	41.9	8.0
20°—30°	25°	145.0	.4630	67.2	0—30°	109.1	20.8
30°—40°	35°	153.0	.6280	96.1	0—40°	205.2	39.1
40°—50°	45°	130.0	.7740	100.5	0—50°	305.7	58.2
50°—60°	55°	79.6	.8970	71.5	0—60°	377.2	71.9
60°—70°	65°	29.9	.9920	29.7	0—70°	406.9	77.6
70°—80°	75°	6.3	1.0580	6.7	0—80°	413.6	78.9
80°—90°	85°	—	1.0910	—	0—90°	—	—
90°—100°	95°	—	1.0910	—	0—100°	—	—
100°—110°	105°	—	1.0580	—	0—110°	—	—
110°—120°	115°	—	.9920	—	0—120°	—	—
120°—130°	125°	—	.8970	—	0—130°	—	—
130°—140°	135°	—	.7740	—	0—140°	—	—
140°—150°	145°	—	.6280	—	0—150°	—	—
150°—160°	155°	—	.4630	—	0—160°	—	—
160°—170°	165°	—	.2834	—	0—170°	—	—
170°—180°	175°	—	.0954	—	0—180°	—	—
Total Lumens of Bare Lamp				525.0	60°—90°	—	—
Total Lumens of Lamp with Reflector				413.6	90°—120°	—	—
Efficiency				78.9	120°—180°	—	—

NOTE.—Lumens=Lumen Constant×Candle-Power.

a character of lighting to which the flux of light idea is particularly applicable. Similarly in semi-indirect lighting with luminous bowls, the light is distributed in the upper hemisphere with ceiling reflections and diffused in part in the lower hemisphere—the effects varying according to the shape of the bowl, the character of glass and positions of the lamps in the bowl. The practical point after all is that lamps are not used bare but in some form of reflector, globe, or bowl fitting; it is not the effect of the lamp alone that counts.

These various conditions, it seems to me, will result in causing the lumen to be used more and more as the unit for the definite expression of the luminous value of lamps and lighting. A great deal of the objection to the lumen is due to the fact that it is a new unit that has hardly come into the experience and practice of very many people in Great Britain. This is not, however, a serious objection, as the unit is easily comprehended and can be readily expressed just as the ordinary candle-power is. The value in lumens of ordinary incandescent lamps is practically ten times the mean horizontal candle-power, *i.e.*, 16 candle-power lamps would have a value of 160 lumens. (This arises as follows:—The mean spherical candle-power of an ordinary incandescent lamp is approximately 0·8 times the mean horizontal candle-power. To convert mean horizontal candle-power into the total flux of light in lumens we must therefore multiply by:— $4\pi \times 0\cdot8 = 10$ approx.).

The diagram given in Fig. 9 illustrates the nature of the lumen. The lumen is, therefore, of the same order as candle-power, except that the lumen takes into consideration the flux of light over a given zone or solid angle, whereas a candle-power, properly understood, states only the value along a single line in any direction.

It would be of value to detail here the application and use of the lumen in practical illumination calculations, but this can be better treated in a paper by itself, which I hope may be presented at some subsequent meeting. It only needs to be stated that lumens provide a very convenient and practical method of

calculating illumination, the following terms being conveniently employed in such calculations :—

EFFECTIVE LUMENS.

The total luminous flux incident on the working plane is called the effective lumens. It may be obtained by multiplying the area of the working plane by the average illumination in foot-candles. The

TABLE IV.

LUMEN DATA FOR METAL FILAMENT (TUNGSTEN) LAMPS, OF SIZES AND EFFICIENCY STANDARDS IN GREAT BRITAIN, JANUARY, 1915. VOLTAGE CLASS, 100--130.

Size of Lamp in Total Watts.		Initial Lumen Values at various Utilisation Efficiencies.															
		Total 1-00	0-45	0-60	0-55	0-50	0-45	0-40	0-36	0-34	0-32	0-30	0-28	0-26	0-24	0-22	0-20
20	110	71.5	66	60.5	55	49.5	44	39.6	37.4	35.2	33	30.8	29.6	26.4	24.2	22	16.5
30	250	162.5	150	138	125	112	100	90	85	80	75	70	65	60	55	50	37.5
40	330	214.5	198	181.5	165	148.5	132	118.8	112.2	105.6	99	92.4	85.8	79.2	72.6	66	49.5
60	500	325	300	275	250	225	200	180	170	160	150	140	130	120	110	100	75
100	900	585	540	495	450	405	360	324	306	288	270	252	234	216	198	180	135
150	1500	975	900	825	750	675	600	540	510	480	450	420	390	360	330	300	225
250	2000	1300	1200	1100	1000	900	800	720	680	640	600	560	520	480	440	400	300
400	4000	2600	2400	2200	2000	1800	1600	1440	1360	1280	1200	1120	1040	960	880	800	600

expression "foot-candles per square foot per watt" can be more simply expressed "lumens per watt."

EFFICIENCY OF UTILISATION.

The effective lumens expressed as a per cent. of the total lumens emitted by the lamps is called the efficiency utilisation. This term is entirely independent of the lamp efficiency, and is frequently called the net efficiency. It depends essentially upon the nature and

colour of the walls, &c., and the amount of light reflected therefrom.

Fig. 10 and Table III. contain a simple photometric record sheet of a reflector with the values of light flux expressed in lumens given in the various zones in the form in which it is desired and employed for illumination calculations.

In Table IV. are given the values in lumens of standard (vacuum) tungsten lamps at the efficiencies at present supplied in Great Britain.

DISCUSSION.

Mr. C. H. WORDINGHAM said that this subject had been one of the keenest controversy for a considerable time, and had now reached a really critical stage. We had almost got to a deadlock in the matter, and those who were interested sincerely wished that there should be an effort made to arrive at a compromise, or, at all events, that some common ground should be found upon which to work. He wished it to be clearly understood that he approached this subject entirely from a general point of view, and not from that of a Government official. The question should be looked at broadly and not from a departmental point of view, which was apt to be narrow; he dealt with it on its merits. This matter might be looked at from three aspects; first there was the manufacturer, secondly the supplier of energy, and thirdly the consumer, that is, the general public. Taken collectively, manufacturers were strongly in favour of rating in watts, but taken individually, with few exceptions they did not seem to care very much about it. The central station man appeared to be dominated by a fear that he was going to be handicapped in his competition with other illuminants, and preferred to mystify a consumer and tell him he was getting a lamp of so many watts, notwithstanding the fact that this had no possible connection in the mind of the consumer with the light which the lamp gave. The central station man also thought that by adopting the watt rating he was going to induce the consumer to keep the watts constant,

and to raise the candle-power, and so keep his account constant. That again was an extremely shortsighted view. If the central station engineer desired to displace other illuminants he must do so by competing in price. If the cost of electric lighting were reduced, its field would be widened enormously. He would like first of all to attack the subject from the point of view of *not* rating in watts. To tell a consumer that he had a lamp of so many watts was equivalent to telling a man that he was to be given a pint to drink, without telling him whether it was to be water or brandy. Mr. Willcox and those who thought with him as the exponents of watt rating regarded the matter from the point of view of the watts input. This would be permissible if the lamps always had an efficiency of 100 per cent., but they had not, and therefore it was necessary to know the input in watts and the output in light. Nobody would think of rating a motor in watts input. With regard to candle-power, Mr. Willcox had been a little unfair in using the term candle-power without any qualification whatever. It was perfectly true that people talked about a lamp of so many candle-power, but in doing so those who advocated a candle-power rating always assumed that the mean horizontal candle-power was understood. This was not always mentioned every time, but it was always implied. It was impossible to tell what a lamp was doing without a candle-power measurement, and therefore we must come back to photometric measurement, whether we rated in watts,

lumens, or candle-power or anything else. It was impossible to know anything about the lamp unless one knew the watts put into it and the candle-power it gave out in every direction. He could not see that it was easier to rate in lumens than in candle-power, as we must come back to the mean spherical candle-power or the total flux of the light. There was a great deal to be said in favour of lumens, but this was only in fact rating by candle-power, though perhaps in a more convenient way. He had a perfectly open mind as between rating in candle-power and in lumens, but he most strongly and emphatically protested against rating in watts input.

The CHAIRMAN, while agreeing with Mr. Wordingham that we had come to a deadlock in this matter, pointed out this Society, owing to its representative membership—including makers and users of lamps, central station engineers, and others interested—was in a specially favourable position to deal with the subject, in a broader, unbiassed manner.

The questions to be determined were, "What should the lamp-maker mark on the lamps?" and "What is it the user chiefly needs to know about its performance?" He thought that the information marked on the lamp should be an adequate description of the lamp's capabilities as a lighting unit. If the present methods of rating and marking were not satisfactory in this respect, then the manufacturers should be told what was wanted and, in their turn, would consider how these requirements could be most easily met. He hoped that the discussion would proceed on these lines and that it would suggest a useful basis of agreement.

A number of written communications had been received, and he would ask the Honorary Assistant Secretary to read these before the discussion proceeded further.

Mr. Dow read communications from Professor SILVANUS P. THOMPSON, Mr. F. W. GOODENOUGH, Mr. E. ALLEN, Mr. HAYDN T. HARRISON, Mr. W. J. A. BUTTERFIELD, and Mr. GEO. KEITH. (See pp. 180-185.)

Mr. C. C. PATERSON agreed very strongly with Mr. Wordingham, that all apparatus should be rated in terms of output, viz., what it is intended to do, and thus on broad principles some rating in terms of light output ought to be adopted for lamps of all kinds, gas, electric, and oil. Information as to the input to a lamp was also wanted, but he did not desire to express any opinion, at this stage, as to whether "round numbers" of input or "round numbers" of output should be adopted.

It had been suggested that lamps have such varying distribution of light that it is very difficult to rate them in candle-power at all, and that consequently we should rate in watts or cubic feet of gas. He had never been able to follow that argument at all. Prof. Silvanus Thompson seemed to adopt the same view when he said that lamps changed in candle-power during life, and that therefore they should be rated in something else which did not change, viz., watts. The watts, however, had little to do with the amount of the light output, witness the difference between the carbon, the vacuum tungsten and the gas-filled tungsten lamps. He submitted, therefore, that the suggested watt rating as a fundamental rating for light sources was not a rating for *light sources* at all, and even intended as a rating for lamps as *energy consuming devices*, was applicable only to electric lamps, whilst oil and gas lamps must be rated on different lines altogether.

Difficulties might arise in arranging exactly what candle or flux rating should be used, but they should decide to employ something which was proportional to the light giving power as a rating. If it were decided to adopt some form of candle-power or flux rating, what was it going to be? We must be clear on what the lamps were being rated for. It would of course be very desirable if it could be said that a certain lamp had a certain rated candle-power which could be used in all calculations to find out what the illumination would be at any point in the neighbourhood of the lamp. Lamps were not, however, ideal point sources, and it was clearly impossible to expect this. They varied in the distribution of their light, and therefore we must give up

the idea of rating being a rigid guide to the illumination at any point. He preferred, as a rule, to look upon the rating as a gauge of the total amount of light given out by a source, and on this basis there should not be difficulty in arriving at a system of rating for all illuminants.

Prof. J. T. MORRIS agreed that it is desirable to rate in output, not in input. On every lamp, as far as possible, the output and input should be marked, much in the same way as in the early days of the carbon filament lamp, the voltage, candle-power, and amperes were marked, together with a letter which gave the efficiency in watts per candle. The author agreed that it was desirable that additional particulars should be furnished to illuminating engineers, such as polar curves of light distribution, to enable them to plan lighting installations. A case had recently occurred in which he had had difficulty in deciding whether to adopt the new "Downlite" Lamp owing to lack of sufficient information, and the only way he could tackle the problem was to secure one of the actual lamps and measure the illumination at certain distances below it. In this way he was able to advise as to the right number of watts needed for the rooms in question; the result was that the watts had been reduced to about two-thirds, whilst the illumination on the working plane had been appreciably improved. He suggested that it might be worth while lamp manufacturers supplying to those interested, not only the polar curve of the lamp itself, but the polar curve of the lamp with the fitting considered most suitable for use with it. Further, it would be valuable to have the illumination figures for a horizontal surface, say 8 feet below the lamp, or better still at two different distances; whilst for high-pressure gas and arc lamps a similar set of figures, say, 20 feet below the sources of light, should be given. From these figures it would be easily possible to predict the illumination in other cases. With regard to the use of the symbol "I" to indicate the mean spherical candle-power, he doubted whether this was desirable, since only in the last few years, and not without some difficulty,

had the symbol "C" for current been changed to "I," and if this symbol were also to be used for illumination confusion would inevitably arise.

Mr. J. MACINTYRE expressed himself strongly in favour of candle-power rating, and agreed that watt rating was no rating at all. One might just as well rate by the size of the bulb. All machinery was rated on the horse-power it gave out. It might be easier for the makers to rate in watts, but as the efficiency of the lamps increased he thought the public would call for a more convenient rating, and one which really gave them some idea of the output in light. Station engineers were very much concerned with steam consumption, and what station engineer would accept an engine which was rated on the amount of steam used per hour? But after all it was not the station engineer who was principally concerned with the lamp, but the consumer.

As to the additional particulars which could be furnished to illuminating engineers this was not a very difficult point. Curves were prepared in estimating from the combination of the lamp and shade. In addition to a polar curve it was usual to prepare a curve which gave the illumination 5 ft. down from the lamp and on a horizontal plane of varying diameter. These two curves were used for comparisons of different combinations of lamps and shades. In specifying interior lighting it was quite possible to specify illumination in so many foot-candles. In cases where the rooms were fitted up with furniture, or in stores, libraries, &c., this might not be so easy to apply to the room as a whole, but in those cases the foot-candle basis must be applied to individual lamps placed in individual positions.

Mr. J. Y. FLETCHER said he would like to correct an impression which most speakers seemed to have, namely, that the makers desired to rate in watts only. He had never heard of such a suggestion from manufacturers. At present they gave the watt consumption and the watts per candle-power consumption as well as the candle-power. Further, from his own experience, he knew that some

manufacturers' catalogues would contain, in future, polar curves of light distribution of each type of lamp.

The CHAIRMAN asked if the candle-power was marked on the lamps.

Mr. FLETCHER said it was not, but lamp makers had always expressed their willingness to do so, but their contention was that it did not instruct the purchaser one whit whether the lamp was marked with 30 candle-power or 30 watts; the purchaser did not know which was true. In saying this he did not mean to suggest that the mark was untrue, but it was impossible for the purchaser to know whether the marking on the lamps was the true marking. If it were in watts only the purchaser could buy a watt-meter for 30s. and test it for himself, but if it were marked in candle-power he would have to buy a photometer which might cost £30 and when he got it would not be able to use it.

The CHAIRMAN asked if lamp-makers would be satisfied to have each type of their lamps certified by the National Physical Laboratory, and a report issued specifying the consumption, candle-power, and polar curve of light distribution.

Mr. FLETCHER: Certainly.

The CHAIRMAN said if this were adopted by all makers it would put all their catalogues on a comparable basis.

Mr. FLETCHER said he would be quite agreeable to this and, further, to put the candle-power not only in the catalogues but on the lamp itself.

Mr. THOMAS E. RITCHIE said that as one largely interested in the arc lamp in its various forms, he would be exceedingly sorry to see the watt rating—or any other system in which the *input* as distinct from the *output* was the determining factor—introduced. It was only when one considered such a rating as applied to arc lamps that one realised to the fullest extent how extremely absurd and misleading it might become.

The variable factors were considerably greater in arc lamps than in many light

sources. A lamp taking, for instance, 460 watts, might actually develop anything from 1,736 to 351 mean spherical candle-power (21,821 to 4,412 lumens), according as it happened to be of the flame, open, or enclosed variety, and again according to the number and character of the globes used upon it and the quality of the carbons with which it was trimmed.

By any method of input rating only each of these lamps would appear to be of the same value. The most inefficient and unsatisfactory article would be placed upon exactly the same plane as the most efficient and most satisfactory, and the user would stand a very good chance of being seriously misled. Further, such method would inevitably tend to a reduction in efficiency, as the stimulus of healthy competition would more or less disappear.

He disagreed entirely with the statements of the author to the effect that arc lamps were now sold on the basis of an input rating (*i.e.*, on the amperes for which they were wound or the watts which they consumed) rather than upon the output yielded. They were certainly not so purchased by the discriminating buyer, and in these days of more general, and more advanced, technical education and methods of thought most large buyers, at all events of arc lamps, were exceedingly discriminating.

His experience was that purchasers of lighting devices were day by day insisting, to a greater extent, upon being provided with definite figures as to the input of energy, the output in light, and the cost of maintenance, and he must say that he had found very many of them quite capable of distinguishing between the various candle-power ratings and of making very close and accurate comparisons.

It had long been the practice of the Company with whom he was associated to give the rating of their arc lamps in mean hemispherical candle-power, either upper or lower, as the case might be, with when necessary a reduction factor for mean spherical candle-power. In the case of those who desired it, and could utilise the information, a polar curve of the complete unit was also supplied, and it was, he thought, only by continuing

to make use of all these factors, and by a willingness upon the part of manufacturers to furnish data and if necessary to *guarantee* the figures given, that accurate and scientific work could be carried on.

He had no objection to the output being rated in lumens if desired; on the contrary, the fact that the lumen rating did not lend itself to any confusion or inadvertent inaccuracy, and had always the advantage of the lumen second as a definite unit, would doubtless be of considerable value to illuminating engineers. He thought, however, that the mean spherical candle-power was more acceptable to the British mind, and was of the opinion that it would be a very long time before it was superseded by anything else.

Mr. J. G. CLARK showed several slides illustrating the various candle-powers that can be attributed to a lamp if no mention is made of the angle referred to. As one representing a gas company he had frequently to advise consumers as to the most suitable lamp to adopt for a particular purpose. He had for a long time advised his principals to accept a complete polar curve together with the consumption as the best expression of the photometric value of a lamp. From such a curve it was possible to calculate mean spherical or hemispherical values in candle-power or lumens, or anything else, and what is of great importance practically, one could calculate heights and spacing ratios for installations.

In dealing with gas lamps it was usual to speak of the efficiency in terms of a standard gas consumption, namely, one cubic foot per hour. It occurred to him that a new term might with advantage be coined to represent the standard rate, and he suggested the word "cubour" to represent one cubic foot per hour, so that the consumption of a lamp would be spoken of as so many cubours. It is usually understood that the consumption when simply stated in cubic feet means that amount every hour, but it would be a good thing to have a special term which could not be misunderstood.

Or we might follow the example of our electrical friends and immortalise Murdock the inventor of gas-lighting just

as they have immortalised Watt. Watt and Murdock were contemporaries. The watt is the unit *rate of consumption* of electricity; then let the Murdock be the unit rate of gas consumption. The expression of so many Murdocks as the consumption of a gas lamp might seem quaint at first, but it was, he thought, worth consideration.

Respecting the specification of definite illumination values by architects and engineers, he saw no difficulty in this: it was, in fact, in his opinion desirable that this should be done, so that those who had to carry out the job could do it in a common-sense scientific manner.

Mr. M. FOULDS said he scarcely understood why there should be any controversy on the matter. He certainly thought that one should know the candle-power of a lamp, and also its efficiency. This fixed the consumption.

Mr. LE MARECHAL, as a manufacturer of lamps, said that makers generally were working towards setting down the total watts to equal the total candle-power; in other words, to work at one watt per candle. In that event it would not seem to matter which basis was adopted.

Mr. WORDINGHAM: Surely you will improve on that.

Mr. LE MARECHAL said makers hoped to do so in the future. He thought there were some advantages in working in watts, but if the public wanted candle-power marked on the lamps there was no objection to putting it there.

Mr. MULLARD said that the public at present fully understand candle-power marking, and that if any alteration were to be made the candle-power should be retained.

Mr. E. STROUD: I think that the most important point in the marking and rating of lamps is its accuracy. There seems to be legal restriction to stop a lamp-maker from marking a lamp at whatever rating he likes, irrespective of the capacity of the lamp itself. This also seems an opportune time to stop the rating of lamps in German Hefner candles,

as this rating gives the lamp a fictitious value of efficiency 10 per cent. in excess of that usually understood. Polar distribution curves of the bare source should of course be supplied, as also any information such as life, &c., of the lamp, but the polar curve of the lamp alone is not of great importance to the consumer, as nobody uses a bare lamp, but always uses some shade or reflector to shade or redirect the light. The combination naturally alters the original distribution of the bare source, so that it should be the duty of the suppliers of the whole unit to publish such curves.

This accuracy of rating lamps is of great importance when working on illumination values, which is the basis of all calculated lighting schemes. I consider that all lamps should be marked *similarly* with voltage, watts consumption, and candle-power (*which should be mean spherical*). This marking is more understandable, and would practically be the same thing as marking in lumens or quantity of light emitted. Undoubtedly the ideal method of marking lamps would be voltage, energy input, and quantity (of light) output.

Mr. R. CLAUDE BUSSELL remarked every one that evening had spoken as though gas and electricity were the only two possible illuminants. He reminded the audience of the existence of paraffin, which, long in world-wide use, could now even become a formidable competitor as a result of modern inventions. If the Council were to adopt the recommendation of the speaker who advocated that cubic-foot-hours should be known as "Murdochs," a plea would have to be advanced on behalf of paraffin for a standard in say "pint-days," which might appropriately be christened "Rockefellers." To be serious, however, he felt strongly that any standard of rating should be common to electricity, gas, paraffin, or any other illuminant that came along.

Mr. F. S. TILLEY, as a manufacturer, was not so concerned as to how lamps were judged so long as a particular measure was adopted which would enable all lamps to be judged on the same basis. It was very disappointing to any manufacturer

who took a very great interest in his laboratory to rate his lamp accurately and upon sending it to different parts of the country to find it judged in totally different ways. This was a very important matter which the Society might take up, viz., to devise rules for the guidance of those who have to test lamps no matter whether electric, gas, or paraffin. There was so much discussion as to the proper method of testing lamps that it was practically impossible to get the same result from different people's tests.

Mr. J. S. DOW said that if one tried to make any kind of general scientific comparison between lamps it was necessary to do so on the basis of the input and the total output of light, *i.e.*, the total flux of light or else the mean spherical candle-power. The essential thing for the illuminating engineer to have was the polar curve. At the Optical Convention two years ago it was interesting to note how many firms started using polar curves with their exhibits, and to-day these were quite common in catalogues; whereas five years ago they were quite unusual. With this information anybody could work out all the details of an installation from first principles.

Then there was the question what data should be supplied to those designing a lighting installation. There were many existing rules, such as that an 8-candle-power lamp would light so many square feet, &c., but in practice the results depended very greatly on the type of lamp and the shade adopted. A much better basis was to state the illumination on the working plane; but even that was not everything, because it was possible to get a very strong illumination on the working plane, and to neglect the lighting of surroundings. In almost all cases a certain amount of general light was needed in the room irrespective of what was wanted on the work. He suggested that we should specify both the illumination on the working plane and the total flux of light in lumens (or the mean spherical candle-power) for a given cubical space.

The CHAIRMAN (Mr. L. Gaster), in winding up the discussion, said there seems to be general agreement that the

voltage, watts, and candle-power of electrical lamps should all be marked on the lamp; and that in addition the polar curve should be available in the literature relating to lamps and lighting units, so that the expert might know what they could do in practice.

He had been very glad to find that manufacturers were agreeable to having tests of typical lamps made at the National Physical Laboratory; if all manufacturers would adopt this practice and would give the results as regards consumption and candle-power, and would furnish the requisite polar curves in their catalogues and other literature, this would at once indicate to the lighting expert in an authoritative manner what the unit was capable of doing. This was a great point gained, and, in itself, was a most useful fact to have been established by the discussion. At present fanciful estimates of the performances of lamps were apt to find their way into catalogue literature, and claims were not infrequently put forward for special forms of lamps which would not stand impartial investigation.

There was no power to make manufacturers mark on the lamp anything other than what they thought fit, and it was therefore essential that the responsible makers should agree on a general correct practice in this respect. It was naturally expected of this Society that it should use its influence with manufacturers to bring about a friendly understanding on these points and, although there were doubtless many details that would require further consideration, he thought that a step in the right direction had certainly been taken.

MR. WORDINGHAM, briefly replying, said that the general consensus of opinion appeared to be that lamps should be rated on the basis of what the user expected to get out of the lamp, and not what he expected to have to pay for it.

MR. F. W. WILLCOX also briefly replied. One main question, he said, seemed to have escaped attention, viz., that the results we have to-day have not been arrived at by theoretical discussions, but by practical evolution. It was natural for scientific theorists to scoff

at the idea of rating a lamp upon its input, but the system had been in practical use for four or five years, had been developed by practical evolution, and was giving every satisfaction. The relation of input to output of a lamp was a very direct, simple, and invariable one, and not complicated as in the case of motors. So far as the user of a lamp was concerned, he believed it conveyed to him just as much information if a lamp were called a 20-watt lamp as if it were called a 16-candle-power lamp.

He was grateful to Mr. Fletcher for emphasising the point that there was no intention of abandoning the candle-power marking. It was easy enough to put candle-power on the lamp, but the point was, should we start with a line of sizes in fixed wattages or in fixed candle-power? At present there was a fixed line of sizes in watts in Great Britain, Canada and U.S.A., and it had proved very practicable. Every engineer knew what he had to deal with and could calculate from the wattage to the candle-power. Yet Mean Spherical Candle-power was quite a mouthful of words and it is easier to think and talk in lumens. He was quite willing to leave the question to the mercies of practical evolution which had carried the matter so far already. Practical conditions have bowled over all theories, and the points of the evening's discussion had simply repeated those raised in the States a year or two back at the time the watts rating came into use. Practical evolution had carried the day and the watts rating remained.

A hearty vote of thanks was accorded to Mr. Willcox and to Mr. Wordingham at the conclusion of the discussion.

PROFESSOR SILVANUS P. THOMPSON (*communicated*):—My view on lamp classification is this: that lamps should be marked with *volts* and with *watts*, and, if desired, with approximate *candle-power* (mean spherical), but that for the "ranging of standard magnitudes" they should be ranged in certain specific values of *watts*—10-watt, 20-watt, 50-watt, &c.—leaving the approximate candle-power to be such values as the makers can attain for the

particular numbers of watts. My chief reasons for this opinion are: 1. The greater constancy during life, of the *watts* of the lamp. 2. The greater ease of verifying the *watts* than of making a mean spherical photometric test.

Mr. A. P. TROTTER (*communicated*):—Some time ago, in the course of a short conversation with Mr. Gaster, he converted me from rating in candle-power to rating in watts. He met all my objections. I forget his arguments, but I have heard a full discussion on the subject and I remain convinced.

My convictions have been supported by my domestic use of "down-light" and of "daylight" lamps, for neither of which horizontal candle-power is suitable. The public who do not know much more about candle-power than they know about watts will soon learn that a watt is rather better than three-quarters of a British candle, and this is rather better than the inferior German thing called a Hefner.

In its proper place the lumen is indispensable, and I shall take refuge in it whenever it will help me in calculation or in expressing myself. But I do not think that as the fundamental unit in photometry or in the commercial rating of lamps the lumen is in its proper place. Lumens per watt is a valuable expression, and should replace watts per candle. But it can only be handled by experts, and is not fit for public use.

As regards the list of symbols, I would suggest the addition of I_h to indicate mean horizontal candle-power: also that I_θ is preferable to I_a as the letter α (alpha) is very apt to become confused with a in printing.

Mr. F. W. GOODENOUGH (*communicated*):—The question of rating and marking units of illumination in such a way that the user can tell exactly what he is buying is a very important one, and if the Illuminating Engineering Society can do anything effective in the direction of establishing standard methods of specifying the illuminating value of such units they will have done useful work.

At present, the buyer who is not equipped with a photometer is largely dependent on the commercial honesty

of the seller, which is often widely different from his personal honesty. He is too often inclined to yield to the temptation of fighting the dishonest man with his own weapons. We want to get away from "nominal" ratings to actual ratings based upon a common standard.

In regard to points set out in the memorandum issued as a guide to discussion, I should like to make the following brief observations.

(1) I see no reason why lighting units should not be rated and marked in both energy and candle-power. The user wants to know what light he will get and what quantity of energy he must pay for in order to get it. If he is only told a lamp is 50 c.p. he will reply "How many watts (or cubic feet) will it consume per hour?" If only told a lamp is a 75-watt or a 2-c.ft. per hour lamp, he will at once ask "What light will it give?" The two factors energy and light are not always in the same ratio one to the other and ought therefore both to be specified.

(2) I do not consider that any necessity exists for the introduction of the lumen basis in lieu of the candle-power basis with which the public is familiar. All that is required is a standardisation of what is meant by the candle-power of a lamp.

(3) In defining what is meant by candle-power, I am in favour of mean spherical candle-power, whilst for the selection of types of lighting unit for various purposes the illuminating engineer needs to have polar curves obtained from the complete unit as it would be used. These would give him the necessary information as to candle-power in particular directions and would enable him to ascertain the mean lower hemispherical candle-power, &c., but it would be more convenient if more data were given as well as the polar curves. It is obviously desirable to adopt recognised symbols as suggested; but the signs for upper and lower hemispherical candle-power should be open and not closed curves, to prevent possibility of confusion in manuscripts or small print. It appears quite practicable to adopt foot-candles on the working plane as the basis for specifications for interior lighting, but the illuminating engineer will of course require from the supplier of the installation a guarantee

as to the hourly consumption of energy required to give *and maintain as a minimum* the specified illumination.

A difficulty obviously exists in the marking of a light unit such as a gas lamp which is composed of several detachable parts—burner, injector, mantle, globe, reflector, &c.—the correct combination of which is required to give the normal lighting efficiency of the unit. The rating of such a unit must necessarily be stated to be subject to the replacement as and when necessary of the mantle by one of similar quality, just as the rating of an electric incandescent lamp must be stated to be subject to its replacement as soon as the filament has become depreciated in lighting power. In other words, the rating of all lighting units must be recognised to be in relation to their efficiencies when new. The particular point that should be emphasised is that if users wish to obtain from the energy they consume the maximum lighting efficiency, they should go to their gas undertaking for mantles which are bought on a quality first basis and submitted to stringent tests, or to their electricity undertaking for advice as to the purchase of lamps, and not ruin a good installation by using “cheap” mantles or filaments to replace those which were capable of giving the specified candle-power.

MR. E. ALLEN (Liverpool) (*communicated*):—I fear that the time has not yet arrived for a standard specification for burners and mantles, as the conditions of pressure and composition of gas are not uniform throughout the country.

At the present moment we have no specification for burners, but have lately tested a large number of burners with the object of finding out which gives the most satisfactory results. The variable effects we have had to contend with are pressure, specific gravity, and composition of the gas. Any and all of these conditions have a very determining influence over the Bunsen flame, and we have ascertained that the best practical burner is perhaps one of the simplest and the cheapest. Burners which have interchangeable parts and which are supposed to be suitable for a special gas, have not proved satisfactory. Swing burners with bayonet fittings perhaps lengthen the life of the

mantle, but if they do not hang perfectly vertical they become an eyesore. Burners which allow the products of combustion to mingle with the primary air, do not give a very good efficiency. The uses of wire gauzes in burners are not successful, because they, like metal nozzles, burn away. The injector plate should not be a thin stamping, but at least a thirty-second of an inch thick so that the holes may be of such a form that a control of the jet is obtainable.

Mantles are purchased by my Company on results from experiments. Tests are made as follows: Three mantles are chosen out of a parcel, one is tested for illuminating power, the second for hours of endurance, and the third is placed upon the shocking machine and tested for strength. In reference to the candle-power, we have made tests of lamps by which we have obtained polar candle-power curves, this result being largely governed by the use of a reflector as well as the position of the mantle inside the lamp.

It appears unnecessary to express the candle-power of a lamp in mean spherical or mean lower hemispherical candle-power. So many factors control the average hemispherical result which may be detrimental to this term. The lamp may be rated at its maximum candle-power on a certain angle. In any case a standard candle-power should be maintained for all illuminants.

MR. HAYDN T. HARRISON (*communicated*):—In my opinion to rate the value of light sources in anything but light units is not only illogical but is also often the cause of serious ophthalmic troubles. For instance, a layman may buy two 10-watt electric lamps, one of which, being of a carbon make and high voltage, gives $2\frac{1}{2}$ mean spherical candle-power, and the other one, being tungsten filament, gives 8 mean spherical candle-power. Eight candle-power on the usual table fitting will give satisfactory results for reading or writing; $2\frac{1}{2}$ candle-power under the same conditions may cause eye strain due to poor illumination, whereas if the lamps had been rated according to their light-giving value this would not have occurred. I do not think it is essential that this light

giving rating need be closer than, say, 5 per cent. or even $7\frac{1}{2}$ per cent., to the actual rated figure, and therefore, even if the lamps are marked in watts or cubic feet per hour, as the case may be, they should also bear marking relating to light-giving value.

As regards whether light sources should be rated in candle-power or lumens, I am inclined to favour candle-power, provided the symbols in paragraph (4) or some such symbols are adopted. This allows the average person to understand in which direction the maximum light will be obtained, and he can adapt the position of the lamp accordingly.

As regards the adoption of lumens or candle-power—the term candle-power has become so firmly fixed in the minds of people in this country that I think a change from candle-power to lumens would prove nearly as difficult as a change from the duo decimal to the decimal system of coinage.

As regards paragraph (5), I have found no difficulty in specifying interior lighting by giving the illumination desired on the working plane. To specify by consumption of watts or gas, as I have already explained, to me appears ridiculous. To specify by candle-power is simply transferring a certain amount of work from the Contractor to the adviser. It is a small detail and I must admit that in practice I have generally found it advisable to specify the actual type of lamp and reflector, but I have always specified it more as an example of what is required, in order that the best thing of its class could be adopted.

Mr. G. KEITH (*communicated*):—The present methods of rating of both gas and electric lamps leave much to be desired. Personally, I am in favour of the power of lamps being stated in terms of mean lower hemispherical value.

Mr. J. W. T. WALSH (*communicated*):—I should like to make a few remarks on the question of the specification of interior illumination by foot-candles instead of by candles per sq. foot. It will, of course, be at once conceded that the quantity about which information is really desired is illumination at the working plane. It is of no value to any one who

has to read a book to know the candle-power of the lamp by which he is reading, except in so far as this affects the illumination of his book. That it is which interests him, and of course the ideal method of specifying illumination is by the unit of illumination, the foot-candle. Unfortunately, until quite recently, the direct measurement of illumination has been attended with much difficulty in practice, and the prediction of the value of illumination which would be attained under certain predetermined conditions was almost impossible. Hence arose the method of specifying a certain number of candles per sq. foot of area of the room to be illuminated, this method presenting no difficulty and giving at least a rough idea of the illumination to be expected from an installation so specified.

With the advent of the modern portable photometer, however, it would seem that the time has come to reconsider our position in this respect. The measurement of illumination is now no longer the laborious process of former days, and it is possible to obtain a very good knowledge of the average illumination in any moderate sized room (say 20,000 to 30,000 sq. feet in area) in less than an hour. This allows for about 50 observations, which should be quite a sufficient number for ordinary purposes. As to the prediction of the results to be expected from a given installation, Prof. Clinton, in his paper before this Society twelve months ago,* showed how accurate a forecast could be obtained from previous data as to the size of room, distribution, candle-power, and polar curves of the lighting units.

But in spite of all that may be urged in favour of the foot-candle, there are naturally many who will cling to the time-honoured method until they see good reason for changing, or until it has been definitely tried and found wanting. With an idea of making a comparison between results obtained by the two methods, I had the curiosity to examine the results given by Prof. Clinton in the paper to which I have already referred. It may, perhaps, be recalled that he there deals with nine widely different systems

* W. C. Clinton, *Illum. Eng.* (Lond.), VII., 189, April, 1914.

of lighting, and from the very full details of the systems used in each case and of the observed illuminations, it becomes an easy matter to compare the candles per sq. foot with the foot-candles at the working plane in each case. The results obtained are tabulated below :—

Description of Installation.	M.H.S.C. sq. ft.	Foot-candles.
1. Workshop with tungsten lamps in metal reflectors	0.45	2.5
2. Drill hall with tungsten lamps in metal reflectors	0.26	2.1 to 2.7
3. Church with tungsten lamps in prismatic glass reflectors (central area only) ..	1.6	3.0
4. Railway booking hall with tungsten lamps in prismatic glass reflectors	0.50	1.5
5. Schoolroom with incandescent gas ..	1.0	5
6. Workshop bench with local lighting ..	—	—
7 and 8. Indirect lighting	—	—
9. Machine shop with flame arcs	2.0	2.6

The above examples sufficiently indicate the probable magnitude of the discrepancies to be met with in the results given by the two methods. Calculation on a mean spherical instead of a mean hemispherical candle-power basis would probably have considerably changed the numbers given in the second column, and it is one of the objections to the candles per sq. foot method that it becomes absolutely necessary to specify the particular candle-power on which the calculations are based. The difficulties of the method are, of course, enormously increased in the indirect or semi-indirect systems of lighting now coming so much into favour. None of these objections can be raised against the direct measurement of the actual illumination in foot-candles, and it is therefore to this method, I think, that we should look for progress in the future.

Mr. F. J. HAWKINS (*communicated*) :—The subject under discussion is much broadened by the fact that different forms of light units have been under

discussion. There is such a contrast in the many forms of illuminants available that the standardisation of a common rating which would apply generally to all forms presents a problem requiring much consideration.

It seems unfair criticism to accuse the manufacturer of adopting such a method of lamp rating that would most easily deceive the public as to the actual output of a unit. Heretofore (and it might even be the condition in the majority of cases at the present day) the average lamp user has undoubtedly been more interested in his lighting bill than his actual "output" in candle power; on the other hand the illuminating engineer, whose object and aim it is to produce the utmost economy and effect from an illumination standpoint, rightly demands to know the exact light distributing power or "output" of a lamp in order to enable him to satisfactorily plan a lighting installation.

The efficiency of lamps being fairly generally known, a wattage rating would be quite sufficient; however, a candle-power marking representative of the M.H.C.P. or M.S.C.P. would certainly be more straightforward for the comparison of different light units, but even this would not be sufficient for the illuminating engineer. Summing up the various arguments put forward—I think the marking of lamps would be just as satisfactory from a public standpoint whether marked in Watts or C.P., but spherical distribution curves of all types of lamps should be available for the benefit of the illuminating engineer.

Mr. H. STANFORTH (*communicated*) :—The importance of a universal method of rating lamps is undeniable, but at the same time it presents many practical difficulties. Referring more particularly to gas units, we find several features in which these differ from electric lamps when considered from the point of view of rating. In the first place, a casing of some kind is essential in most gas lamps, and a certain amount of reflection is obtained therefrom, if the inside of the casing is enamelled or of polished metal. Then, again, it is generally necessary to use some type of glassware to protect the mantle from draughts, and though

this may be clear glass it is possible to vary the distribution of the reflection on to the surface of the glass, or by refraction. In the case of lamps of the type used for the outside lighting of shops, it would be necessary to test these complete, which would entail the blackening of all reflecting surfaces.

Different results are obtained by varying the arrangement of the mantles in those lamps where clusters are used, but of course it is the business of the manufacturer to determine the best arrangement. It should therefore be possible to rate gas lamps as though they were without reflectors, but it will be understood that if a test were taken at or about the horizontal with a cluster lamp, a much lower result, stated, say, in candle-power per cubic foot of gas, would be obtained than in the case of a single mantle lamp; but I fail to see of what interest or use this value can be to the illuminating engineer, as distinct from the lamp manufacturer, when it is considered that in use the lamp will in all probability be fitted with a reflector, and also glassware, which has a decided effect upon the light distribution.

For instance, a bare lamp might be rated as a 100 c.p. unit, but that value would not be of any use to the illuminating engineer if the complete unit carried, say, a concentrating reflector which so altered the distribution that there was equivalent to 300 c.p. directly beneath the lamp, and all light cut off at 45° . What in my opinion conveys the most information to the illuminating engineer is a polar curve showing the light distribution, along with the gas consumption and pressure—in the case of the gas lamp—when the curve was taken.

Take the case of low pressure gas lamps for street lighting. Here the greatest difficulty is to obtain sufficient illumination at a point mid-way between the lamps, and it is only by using suitable reflectors that a reasonable illumination is secured at that point. I quite fail to see what useful purpose would be served in the case of that kind if it were known that the bare mantle gave, say, 150 c.p. at some particular angle. There always appears to be this same difficulty when the output of a lamp is considered in lumens or any other aggregate value

which does not convey any information with regard to the distribution of the light. The total flux of an illuminant may be quite satisfactory, and yet the distribution may be defective for a particular purpose. For instance, it is quite possible to get a dense shadow, say, directly beneath the lamp, and yet from a flux of light point of view the unit might be quite satisfactory.

For the same reasons I do not think that stating the value of lighting units in terms of mean spherical candle-power, mean hemispherical candle-power, or candle-power in a particular direction, conveys the information that is required by the illuminating engineer when laying out a lighting scheme.

I quite agree that it is much better to state the illumination on a working plane in foot-candles rather than working on a wattage or consumption of gas basis, and certainly it is to be preferred to the candle-power per square foot of floor area, irrespective of the requirements at particular points. It is quite a simple matter to prepare tables or curves giving the c.p. required at any angle and at a particular distance from the plane to be illuminated for an illumination of, say, 1 foot-candle on a normal, vertical or horizontal plane, and to work back very readily from these figures the illumination with any other state of conditions. Such values as mean hemispherical c.p., total flux, &c., would be of use if all lamps had similar distribution curves, but with the multitude of reflecting arrangements on the market, each giving a different light distribution, I think it is preferable to work from the polar curve basis, provided the conditions under which the curve is obtained are also stated.

MR. W. J. A. BUTTERFIELD (*communicated*):—The symbol I_a should be consistent with $I_\circ$ and I_σ , *i.e.*, should represent the candle-power at an angle α with the horizontal. I should prefer a symbol which would indicate clearly that this is the case, *e.g.* :—



to indicate angles of 45° and 30° below the horizontal.

SEARCHLIGHTS IN THE POLISH CAMPAIGN.

ACCORDING to the official Russian report searchlights played a very important rôle in recent operations in Poland. It is stated: "The Germans under cover of darkness attacked in compact masses, but the enemy, lit up by our searchlights, were decimated by our fire."

In such cases, clearly, "light on the object, not in the eye," is the principle adopted, and the searchlights, besides directing the Russian fire, acted as a species of glare to their opponents.

STATISTICS ON STREET LIGHTING.

A PAPER on street lighting was recently read by C. B. Babcock before the Pacific Coast Gas Association.*

The author gives some statistics showing the development in the respective quantities of gas and electric lamps in various American and Continental cities.

He remarks: "It is well to review the municipal lighting situation as it faces the gas men to-day. In the City of New York there are 44,000 gas mantle lamps and 17,991 incandescent electric lamps; Philadelphia, Pa., has 23,719 gas mantle lamps with 14,616 electric lamps, and 19,105 gasolene lamps. In Boston, Mass., there are over 14,000 gas mantle lamps; in St. Louis, Mo., over 18,000."

In connection with gas street lighting in English cities, it is interesting to note that "in the City of London there are 3 public gas lamps to 1 electric; in Perth, Scotland, 11 gas to 1 electric; in Aber-

deen, 20; in Glasgow, 22; in Dundee, 62; in Edinburgh and Leith, 9; in Manchester, 220; in Bradford, 141; and in Liverpool, 122." London has 65,000 gas mantle lamps, and about 4 years ago the entire western section of the city (Westminster) changed over from electricity to gas for the reason that the latter was considered far more efficient and economical. In fact, a saving of \$40,000 a year was brought about by the change to gas. There are altogether in Great Britain 771,016 public gas lamps.

MACHINE TO REGISTER FATIGUE.

ACCORDING to *The Globe* M. J. M. Laby, member of the French Academy of Sciences, in a communication to the Academy has declared that he had studied practical means of scientifically organising the division of labour by determining the degree of fatigue entailed by modern professions that do not demand great muscular exertion. Experiments carried out since 1903 on post-office sorters, printers, linotype operators, and typists, had given absolutely concordant results. The degree of fatigue was determined by the increase in the arterial pressure and the time of the subsequent reaction.

It would certainly be interesting to ascertain whether this instrument could be applied to determine the comparative conditions of fatigue resulting from the use of various methods of illumination.

By some such test we might gradually find out which are the defective conditions of lighting that cause fatigue, and add to the strain of industrial occupation

* *American Gas Lighting Journal*, September 28th, 1914.

TOPICAL AND INDUSTRIAL SECTION.

— • • • —

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

EDISWAN ITEMS.

The Edison & Swan United Electric Light Co., Ltd., Ponders End Works, Middlesex, were visited on Wednesday, February 24th, by the members of the Chemical Society, Royal College of Science, South Kensington, Mr. E. W. Swann, their Excursion Secretary, being responsible for the arrangements.

An interesting visit was made to all the lamp manufacturing departments, including carbon and drawn wire sections.

A contract has been accepted by the Booth Steamship Co. for Royal Ediswan metal filament and carbon filament lamps.

A recent Ediswan leaflet contains particulars of special fans for steamship and train. Another feature is the special Ediswan Dimmer switch illustrated herewith, with "on," "off" and "half"



positions. It will run a 30-watt lamp down to one candle or a 40-watt lamp down to 5 candles, and will also reduce the speed of standard 12-in. fans to about half speed.

SIEMENS CONTRACTS.

Messrs. Siemens Bros. Dynamo Works, Ltd., announce acceptances of the following contracts for the ensuing twelve months:—

Carbon filament lamps for the London County Council.

Wotan, Wotan half-watt and carbon filament lamps for the Aberdare Council.

Wotan and tantalum lamps for the Middlesbrough Corporation.

Wotan, tantalum and carbon filament lamps for the Croydon Corporation Tramways.

SOME G.E.C. PRACTICAL FITTINGS.

Several practical forms of fittings for workshop and office use have recently been introduced by the General Electric Co., Ltd., One of these is a standard of substantial construction standing about 5 ft. high. The stem is of ash wood on a massive iron base. It carries a transverse wood rod to which is attached a G.E.C. fibre insulated hand lamp. In no part are metal parts in contact with current-carrying wires, and the Home Office requirements are entirely met.

Other novelties of interest include a new form of telescopic bracket capable of up and down motion as well as swing in a vertical plane; the direction of light from the lamp in reflector at its extremity is also readily adjustable.

NONPAREIL INVERTED INCANDESCENT GAS SUNBURNER.

A leaflet issued by Messrs. Jas. Milne & Son, Ltd., illustrates the Nonpareil Sunburner. An interesting installation of these lamps, at the Leeds Training

College, was referred to in this journal not very long ago.

The light consists of a series of inverted burners mounted under a hood in such a way that besides furnishing a strong downward illumination they have a considerable value for [purposes of ventilation. A 28-light of this kind gives as much as 2,100 candles. It is doubtless an advantage that with this number of mantles the fact of any individual mantle deteriorating will not much influence the performance of the unit as a whole.

A considerable number of these units appear to be now installed in London and the provinces.

HOW TO PLAN LIGHTING INSTALLATIONS.

In our last issue (p. 145) we made a preliminary note on the new B.T.H. reflectors for industrial lighting, several of which are illustrated in the adjacent column. The most interesting section of the catalogue information referring to these reflectors is the suggested method of planning installations.

We have described how each reflector has its appropriate combination-symbol which, to the initiated, tells the whole story of its type, and distribution of light and the size of lamp for which it is intended.

In addition to this a couple of key-tables are provided, the first of which divides lighting problems into ten main classes, according to the nature of the work, while the second merely gives the symbols identifying reflectors of varying concentration. By the aid of the chart, shown on the opposite page, the spacing, type of reflector, and size of lamp can be determined. Naturally some judgment and initiative is left to the user of the table; he must, for example, decide correctly the class to which his installation belongs, and he must also make certain decisions as regards spacing.

Altogether the scheme is an ingenious one. There is, however, one addition we should like to see, namely, some indication to the consumer of the resultant illumination with a given arrangement of lamps and reflectors. No doubt, by referring to the polar curves he could work this out from first principles; but it might, perhaps, be made easier for him by another tabulation.



Typical housing for use with "half-watt" lamps. Similar cases for a great variety of shapes of lamps are available.



Typical 15° angle Mazdalux reflector; this type is designed both for half-watt and ordinary lamps.



Special local lighting type of Mazdalux reflector with wire cage for factory use. A feature of this unit is the locking arrangement so that neither lamp nor reflector can be removed when sealed.

ADVANCE IN PRICE OF FITTINGS.

The British Thomson-Houston Co., Ltd., advise us that from April 7th onwards there will be a 10 per cent. advance on the price of their fittings.

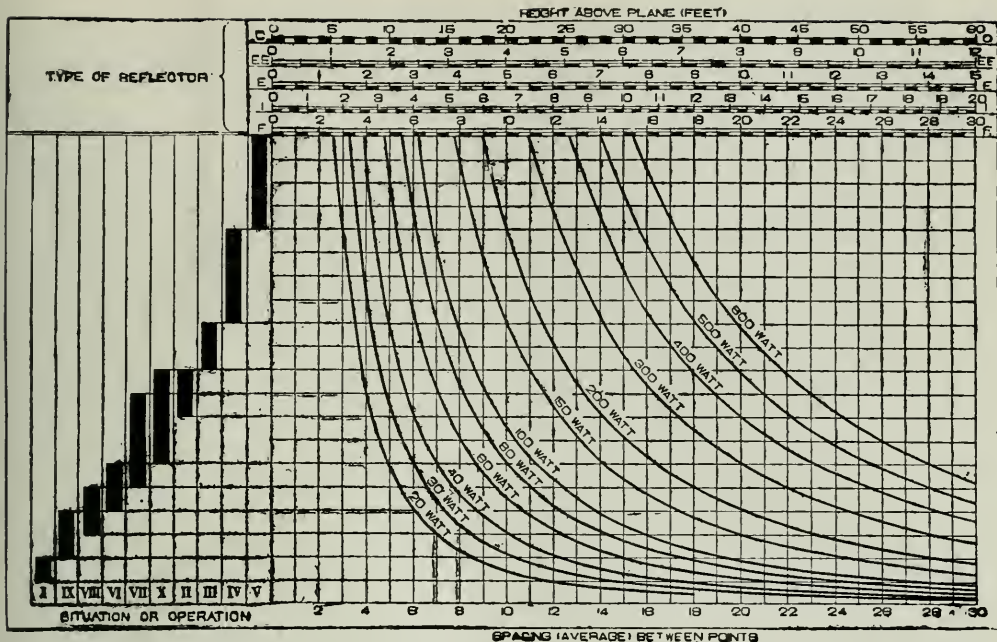


CHART FOR PLANNING LIGHTING INSTALLATIONS.

The application of this chart can only be fully understood by reference to the complete catalogue. The Roman figures at the base of the diagram indicate certain classes of work, tabulated in the catalogue (such as I. stores, II. offices with local lighting, III. tool-making and fine fitting, &c.). Having decided in what category the job falls, we identify the black space on the left and follow

horizontal and parallel to this until we meet the vertical line corresponding with the spacing of units preferred (settled mainly by height of ceiling and character of work). The point of intersection with this vertical line gives the size of lamp required. The correct height for the various reflectors (indicated by capital code letters) is set out at the top of the diagram.

GLASSWARE TO GIVE SUNLIGHT COLOUR VALUE WITH INCANDESCENT ELECTRIC LAMPS.

The British Thomson-Houston Co. are putting on the market a complete range of colour-matching pendants and globes to which the name "Trutint" has been applied. We had recently an opportunity of inspecting these globes at Mazda House.

The glass is made in three types according to the class of work for which it is intended, *e.g.* :—

(1) Very accurate matching in colour comparison work, for local use where there is little interference from extraneous light.

(2) The general illumination, giving a light of "noon" sunlight value, suitable for general lighting of paint shops, lithographic plants or art galleries, &c. The efficiency of half-watt units of this class is practically the same as that of the ordinary metal filament lamps in a white opal globe.

(3) General illumination giving a light of "afternoon" sunlight value. This is somewhat more efficient than (2) and gives a somewhat yellower light.

This range of units will, it is hoped, be of considerable value in colour-matching trades and the combination of the blue tint with the diffusing quality of the globes is distinctly novel.

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

The Electrical Engineer's Diary for 1915.
 Edited by J. H. Johnson, M.I.E.E.
 (S. Davis and Co., 30-31, St. Swithin's Lane, E.C.)

DURING the past few months we have had an opportunity of examining—and using—this useful diary. The 1915 edition is considerably larger than that available in 1914, the printed matter occupying 274 pages. The list of technical terms and definitions has been revised and expanded. Lighting terms and definitions receive treatment in a special section. The notes on interior, street and industrial electric lighting are quite serviceable, and the data given for the capacity of motors required in various trades exceptionally complete. The series of "Don'ts" addressed to electrical contractors also deserve notice. Another useful feature—on which we commented in a previous edition—is the list of streets served by the various electrical supply companies in London. Altogether a most useful publication.

Gas Supply in Principles and Practice.
 By W. H. Y. Webber. (Whittaker and Co., 2, White Hart Street, London, E.C. 1914. 3s. 6d. net.)

MR. WEBBER is an old hand at this subject, and his book on "Town Gas and its Uses" is probably known to most of our readers. His latest work conveys a considerable amount of up-to-date information. The earlier portion deals with the distribution of gas, gauges, meters, &c. Subsequently we have an example of typical house piping for a dwelling rented at £35—£45 a year, and notes on such questions as the combustion of gas, illuminating v. calorific powers, &c. The account of lamps and burners is brought up to date by a reference to the Keith Silica Lamp, and semi-indirect fittings, &c.

The portion of the book that most interests us is that dealing with lighting. We are glad to see that the author lays stress on the avoidance of glare; and, while quoting the general rule of allowing 30-50 candles per 1,000 cub. feet of interior, also mentions the illumination in foot-candles required for various purposes.

There are also notes on the lighting of shops, engineering works, public halls, &c.

The latter part of the book is devoted to a study of the Bunsen flame as a heat-producer, leading up to modern forms of stoves and radiators. The appendix

contains a glossary of technical terms, in which, however, we might suggest that a few more of those used in connection with illumination should be included.

Practical Illumination by Justus Eck.
 (S. Rentell and Co., London. 1914. 1s. net.)

MR. ECK'S "Pocket Book" was published in 1914, and is doubtless known to all his friends in the Illuminating Engineering Society, and to many other readers of this Journal. Within the 85 pages it contains a considerable amount of useful, data and it is fully illustrated. Examples of lighting by both direct and indirect systems, using both arc and incandescent lamps, are given.

The account of the chief methods of indirect lighting, and the distinctions between "inverted," "indirect" and "semi-indirect" are systems in particular, are good, and the tables giving the correct spacing of lamps at various heights, and the illumination resulting from the allowance of a certain area per lamp (of stated amperage), should be useful. Examples of their application to various practical cases are given. The book is concluded by a series of tables enabling cost of carbons at various rates per hour to be calculated.

Established
1855.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.
 Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
 Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
 OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES

Of Life Assurance, with Various Options

All Classes of Insurance Business Transacted

CHIEF OFFICES:

General Buildings, Perth, Scotland.
 General Buildings, Aldwych, London.
 General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, April, 1915.

	PAGE
Editorial	L. GASTER .. 149
Illuminating Engineering Society—	
(FOUNDED IN LONDON, 1909.)	
Account of Meeting on March 16th	161
The Rating and Marking of Lamps and the Best Methods of Specifying their Illuminating Value. <i>Queries on</i>	162
<i>Discussion</i> —F. W. Willcox—C. H. Wordingham—L. Gaster—C. C. Paterson—J. T. Morris—J. Macintyre—J. Y. Fletcher—T. E. Ritchie—J. G. Clark—M. Foulds—M. le Marechal—Mullard—E. Stroud—R. C. Bussell—F. S. Tilley—J. S. Dow—Prof. Silvanus P. Thompson—A. P. Trotter—F. W. Goodenough—E. Allen—Haydn T. Harrison—G. Keith—J. W. T. Walsh—F. J. Hawkins—H. Staniforth—W. J. A. Butterfield	163
Illuminating Engineering, Short Notes on	186
Practical Rating of Lamps, The	F. W. WILLCOX .. 163
Reviews of Books—	
The Electrical Engineers' Diary for 1915, Edited by J. H. Johnson	
Gas Supply in Principle and Practice, by W. H. Y. Webber	
Practical Illumination, by Justus Eck.. .. .	190
Searchlights, A Method of Determining (<i>concluded</i>)	A. BLONDEL .. 153
Searchlights, Some Remarks on the More Usual Electrical Systems of Operations	J. F. CROWLEY .. 159
Topical and Industrial Section—	
Ediswan Specialities—G.E.C. Fittings—Siemens Contracts—Nonpareil Sunburner	187
How to Plan Lighting Installations	188
"Trutint" Glassware	189
Insurance Coupon	191
Gaslighting Factory Installation—Use of Gas for Industrial Purposes	192

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL

ACCIDENT FIRE AND LIFE

ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.

GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.

F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

LOW PRESSURE GAS LIGHTING IN A BODY-BUILDING SHOP.

WE are indebted to the Gas, Light and Coke Co. for this illustration of the gas lighting of a body-building shop (Messrs.

photographer, and usually impracticable, unless the illumination is very brilliant.

The lighting is arranged to concentrate the illumination on the benches where the work is carried on. It is to be noted that



Van den Plas, Ltd., Westminster). The photograph, taken entirely by the artificial light, is interesting as showing figures at work—always a difficult task for the

the glass globes of the lamps are protected by wire with a view to avoiding any possible injury from adjacent pieces of wood, &c.

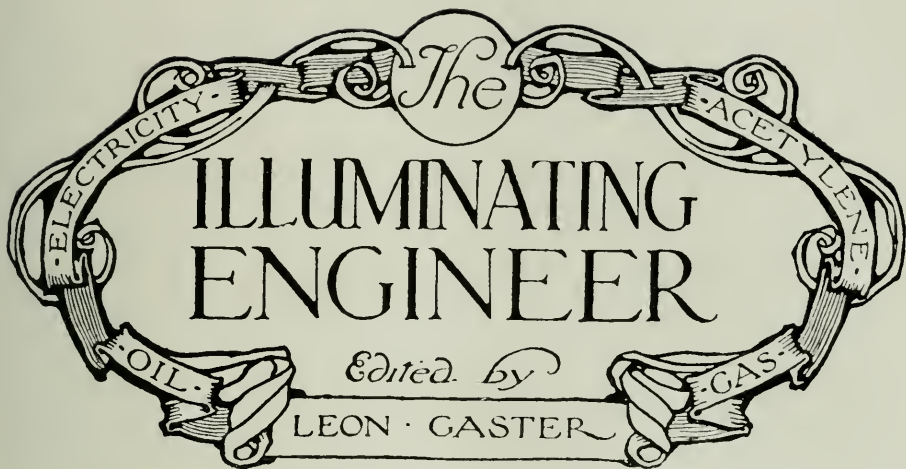
THE USES FOR COAL GAS FOR INDUSTRIAL PURPOSES.

AN important paper on the above subject was read by Mr. H. M. Thornton before the Royal Society of Arts on March 19th, Mr. D. Milne Watson being in the chair. As the title implies, the paper dealt with uses of gas other than lighting, but the figures quoted by the lecturer sufficed to show the magnitude of some of these industrial applications.

Some instances of large gas-driven electric-generating sets were mentioned,

and a complete account of the heating of large reverberatory furnaces, and the application of gas-heating to hardening, annealing, metal-melting was given. Gas is used for such diverse trades as sugar melting, glass manufacture, cloth industry, hat trade, &c. Of particular interest was the account of the great part being played by gas in the production of munitions of war.

The chairman, Mr. W. E. Price, Mr. F. W. Goodenough, Sir Henry Trueman Wood, Mr. Leon Gaster, and Mr. Campbell M. Hunt joined in the discussion



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.
32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

Factory Lighting in War Time.

During the nine months that have elapsed since the outbreak of war there have been gigantic industrial changes. This has been a period of general activity. Factories previously devoted to munitions of war have been spurred to new efforts, and are working at the utmost pressure. Others have been converted to military and Government work and are rapidly adapting themselves to entirely new conditions; others, again, are striving with depleted staffs and broken connections to make good the havoc caused by the interruption of customary channels of trade. Everywhere in this country there is unceasing work—even in those cases in which the commercial loss has been heavy.

In view of these facts the lighting industry should not lose the opportunity of pressing home the value of good industrial illumination. Outside

lighting at the present time, especially in London, has been badly hit ; factory lighting provides an opportunity of recouping, to a considerable extent, the loss in this direction.

The paper by Mr. A. E. Broadberry before the Eastern Counties Gas Managers' Association on Thursday, April 29th, gave an encouraging account of experience in Tottenham, where there are many large factories. From the writer's professional experience he can corroborate Mr. Broadberry's remark that the pressure of extra work and long hours has been the means of impressing upon factory owners the economic value of proper industrial illumination.

All must recognise the great progress made both in high pressure gas lighting and in the modern varieties of electric lighting, but at this stage we do not wish to enter into comparisons between the two illuminants. As the author pointed out the question is a very complex one, and one cannot base such comparison only on the cost and efficiency of the lamps. The flexibility of the system of lighting, the capacity for bringing lamps near the work, the possible applications of gas or electricity for driving machinery, heating, &c., and other local conditions often influence the decision. One must also bear in mind the special nature of the operations in the factory, and consider whether general illumination or local lighting by separate small units are needed. These are factors which often favour one or the other illuminant. We may mention in passing a very enterprising step recently taken by the Tottenham and Edmonton Gas Company, namely, the supply of electricity in one section of their area. Consumers in this district can thus make a choice between the two illuminants supplied by the same company.

One feature in Mr. Broadberry's paper we should like to emphasise—the figures given for the illumination available in the working plane. It is now recognised that data respecting the candle-power of lamps alone are not sufficient and that they should be supplemented by measurements of illumination. We are glad to see that gas and electrical engineers both accept this view ; by the publication from time to time of such data we shall gradually acquire a knowledge of the requirements of various industrial processes. We should like, however, to see such investigations extended considerably and carried out by recognised independent experts. In making comparisons of the merits of different systems of lighting it is desirable that examples of the most recent and up-to-date installations should be taken in both cases. It would, for example, be a mistake to compare the most up-to-date electric installation with an antiquated gas installation or vice versa. This is important not only from the public standpoint but in the interests of those representing the competing illuminants, since without such impartial investigation, they are naturally not in a position to determine where the advantages of their systems lie, and in what directions they can be most usefully employed.

The writer could mention several instances of high pressure gas lighting installations in which excellent results have been obtained.

Another point brought out by many of the striking photographs shown by Mr. Broadberry was the value of proper methods of shading. At the present time good factory lighting, both gas and electric, involves the careful distribution of light on the goods, and makers of both types of lamps now recognise this fact. We are glad to see that the introduction of the electric "Half-Watt" lamp has already been followed by the design of a variety of suitable reflectors.

Visibility—its Practical Aspects.

The discussion on this subject initiated by Mr. C. C. Paterson and B. P. Dudding at the last meeting of the Illuminating Engineering Society, proved a useful supplement to the discussion on searchlights last February. We have here two distinct aspects of the subject, (1) the physical problem of the brightness of the searchlight beam and (2) the physiological problem of the impression received by the eye from the distant illuminated object. Prof. Blondel, in his exhaustive contribution in our February and April issues, has shown how closely these two aspects are correlated, and the discussion at the last meeting again illustrated how many practical problems there are into which these physiological considerations enter. The appearance of distant coloured lights (such as ships' lights, railway signals, &c.) the effective value of motor-car and locomotive headlights in revealing obstructions on the road or line, the effect of shadow and contrast in determining the appearance of small objects illuminated by direct and indirect light—all these are problems in which the illuminating engineer is naturally interested.

Another important point touched upon by the authors was the effect of bright lights in causing glare. Dr. Ettles pointed out that quite a variety of factors play a part in such cases—notably the state of adaptation of the eye. A person who has spent some time in a dark room is dazzled even by the light of a match, the glaring effect of which would be inappreciable in daylight. Here the colour of the light is of some consequence in view of its effect on the peripheral region of the retina—a point which was shown by Dr. Watson to have a bearing on the conditions by night experienced by the soldiers in the trenches.

Another matter of topical interest is the rating of the power of headlights and searchlights. In the present circumstances the authorities are faced by a particularly difficult problem in determining when lights exceed the permissible limit. Naturally cases of inconsistency occur. There seems a need for some simple and practical method of testing the power of headlights, and it is possible that, as a result of theoretical researches, some simple method of this kind could be contrived. This is one of those cases in which special technical assistance is badly needed. We understand that the Motor Car Association are attempting the solution of the problem and it is probable that the Illuminating Engineering Society, whose members are accustomed to the estimation and measurement of the illuminating power of sources of light, might be able to render effective assistance.

Finally one may refer to another important application of the principles of visibility, namely, the art of rendering objects inconspicuous to the enemy. The selection of soldiers' uniforms has been the subject of considerable study on the part of the nations engaged in the present war. When one considers, too, that the effectiveness as scouts of certain branches of the service, submarines, aircraft, &c., depends largely on their being as inconspicuous as possible one realises the importance of scientific researches in this direction. The authorities are naturally engrossed in the tremendous task of carrying on the war, and have no leisure to initiate such researches, but this should not be the case in the future and even at present it is possible that something useful might be effected by the organised efforts of scientific non-combatants.

Science in the Daily Press.

On pp. 203—207 in this issue we give an account of the paper read by Professor Gregory, Assistant Editor of *Nature*, before a recent meeting of the Circle of Technical, Scientific and Commercial Journalists, on the above subject. Prof. Gregory quotes some amusing instances of popular errors which have appeared in the daily press, and many of those present at the meeting were able to give similar cases of mistakes on technical and engineering matters. It is a curious anomaly that references to technical and scientific matters in the daily press not infrequently contain errors which would never be tolerated in respect to legal, literary or political matters. Inventions which would not for a moment stand criticism at the hands of a scientific audience, are described in glowing and sensational terms. Events of high importance in the scientific and engineering world are passed over or presented in a superficial or incorrect manner.

In the present circumstances such mistakes are easily made. There are several leading dailies which employ a technical staff and know where to turn for first hand information on scientific subjects. Others, however, have not these facilities and it is hardly surprising that paragraphs on unfamiliar subjects hastily compiled by journalists with no scientific knowledge should lack accuracy and precision. Something is needed to bridge the gulf between the scientist and the ordinary public. The daily press could render great services to science by making its aims more widely known and securing for it a larger place in the estimation of the people. It has often been urged as a reproach against this country that it did not appreciate scientific knowledge and research at their true value, that it lagged behind other countries in the encouragement of the applied science. Let us hope that one result of this unhappy war will be to bring about a change in this respect.

The most natural channel of information on scientific and technical matters is the journalist who devotes his time to these subjects. The editor of a technical paper, if not a literary genius, has at least a working knowledge of his subjects and understands the needs of the industry with which he is brought in contact. He, therefore, is the man to whom the daily press should most naturally apply in time of need. Most papers, we believe, would go to considerable trouble to ensure that their information was correct, and they are patriotic enough to welcome suggestions as to how the scientific and technical resources of the nation could best be utilised.

At the March meeting it was suggested that articles on important scientific and technical subjects should preferably be signed by a responsible journalist ; or, if unsigned, that they should be referred to a reader having a special knowledge of the subject in question. Arrangements are being made to prepare, from the members of the Circle, a list of gentlemen willing to act as readers of articles dealing with their special subjects. There are many cases in which their services would doubtless be appreciated by the daily press, and a little more co-operation between the technical journalist and the daily press should prove most beneficial to our industries.

This matter is of special importance to the lighting industry since the relative merits of lighting appliances are particularly liable to misrepresentation.

Surely the public have a right to be kept fully informed as to the value of the appliances they are using in order that they may appreciate and take advantage of genuine improvements in the art of illumination.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

CONTRACTS FOR FACTORY LIGHTING.*

A very interesting paper on the above subject was read at the last Annual Convention of the Illuminating Engineering Society in the United States by O. R. Hogue and A. O. Dicker.

The Commonwealth Edison Company in Chicago has adopted a special method of charging for electricity supplied to factories in that city. In the form of contract there are three charges: for (1) rental, (2) maintenance, (3) electricity. One great advantage of this is that it meets the case of the factory manager who believes in improved lighting but finds a difficulty in meeting the high first cost of installation. Accordingly, the company makes a practice of undertaking to install the lighting equipment on the most up-to-date lines, and the cost is spread over a period of two years, at the end of which the installation becomes the property of the consumer.

Not only this, but the company also undertakes the maintenance, furnishing a ten-day cleaning service, renewing all burned-out lamps, and keeping the installation in good working order. This

is covered by the maintenance charge which, however, is not made during the months of June, July, and August.

The advantage of this system of control is obvious. The installation is carried out on standard principles, and it is to the company's interest to see that the consumer is satisfied and that the conditions of illumination are adequate for the work in hand. In addition the company does not lose sight of an installation, but keeps it in good order, recommends changes from time to time as improvements in lighting appliances are introduced, and generally ensures that an originally good installation does not suffer from neglect. The importance of this can be understood from the recent researches of Mr. C. E. Clewell* who shows that the accumulation of dust on shades and lamps in factories, during three weeks' neglect, may cause a 50 per cent. diminution in illumination.

The authors illustrate their paper by a complete series of data on a number of typical installations. The cost of installation in the examples quoted varies from \$2.76 (11s. 6d.) to \$9.88 (£2 2s.) per unit.

The "total cost per square foot per month" varies from 0.156 cents (-08d. approx.) to 1.440 cents (-72d.).

* "Factory Lighting" by O. R. Hogue and A. O. Dicker, Transactions of the Illuminating Engineering Society, Vol. 9, 1914, p. 86.

* Factory Lighting.

ELECTRIC LIGHTING OF METAL WORK PLANTS.

A RECENT paper before the American Illuminating Engineering Society on this subject by A. L. Powell and R. E. Harrington* serves to show the variety of metal working operations with which the expert lighting engineer has to deal. Below we tabulate some of their suggestions for different branches of work. Naturally in the paper fuller details are given.

Besides attending to the general requirements of such shops as regards avoidance of glare and inconvenient shadows, freedom from flickering, &c., it is necessary to study these operations in detail and to select both the reflector and the positions of lamps with care. The following table will give an idea of the variety of operation and the consumption of electricity usually found necessary.

METAL WORKING OPERATIONS.				Watts per sq. foot.	
Nature of Work :—				REMARKS.	
ORE WORKING—					
<i>Crushers</i>	..	..	..	General even illumination impracticable ; adequate lighting of passages and at special points where work is done (racks, separators, hoists)	—
<i>Concentrators</i>	..	..	..		
<i>Racks, etc.</i>	..	..	..		
EXTRACTION—					
<i>Smelting</i>	..	..	..	In furnace work only sufficient illumination for safety, repairs, charging, &c.	—
<i>Blast furnaces</i>	..	..	..		
<i>Puddling</i>	..	..	..		
<i>Crucibles</i>	..	..	..	In electrolytic work even general illumination preferred	0.2—0.5
<i>Bessemer Converters</i>	..	..	..		
<i>Open Hearth Furnaces</i>	..	..	..		
<i>Electrolytic Refining</i>	..	..	..		
METAL WORKING—					
<i>Casting—</i>					
<i>Moulding</i>	..	..	..	Good general illumination for large work Local lighting at benches	0.5—1.0
<i>Core-making</i>	..	..	..		
<i>Charging cupolas</i>	..	..	..		
<i>Pouring</i>	..	..	..		
<i>Tumbling</i>	..	..	..		
<i>Cleaning, chipping, etc.</i>	..	..	..		
<i>Rolling—</i>					
<i>Shingling</i>	..	..	..	General illumination	0.35—0.65
<i>Steam Hammers</i>	..	..	..		
<i>Rolling (various operations)</i>	..	..	..		
<i>Forging—</i>					
<i>Hand Anvil</i>	..	..	..	General or “ Localised General ” illumination	0.3—1.0
<i>Machine, drop and press</i>	..	..	..		
<i>Tempering and Hardening</i>	..	..	..		
<i>Cutting or Machine Tool Work—</i>					
<i>Lathes</i>	..	..	..	General or “ Localised General ” illumination	0.3—1.4
<i>Planers</i>	..	..	..		
<i>Shapers and Slotters</i>	..	..	..		
<i>Drilling and Boring</i>	..	..	..		
<i>Milling machines</i>	..	..	..		
<i>Grinding</i>	..	..	..	ditto	0.35—1.45
<i>Saws</i>	..	..	..		
<i>Bench Work</i>	..	..	..		
<i>Wire Working—</i>					
<i>Cold Drawing</i>	..	..	..	ditto	0.3—0.75
<i>Weaving</i>	..	..	..		
<i>Twisting</i>	..	..	..		
<i>Finishing</i>	..	..	..	ditto	0.35—1.05
<i>Sheet Metal Working—</i>					
<i>Punching</i>	..	..	..		
<i>Pressing</i>	..	..	..		
<i>Shearing</i>	..	..	..		
<i>Spinning</i>	..	..	..		
<i>Buffing</i>	..	..	..		
<i>Assembly</i>	..	..	..	General	0.4—1.2
<i>Erection and Testing</i>	..	..	..		
<i>Painting</i>	..	..	..		

* Trans. Illum. Eng. Soc. U.S.A. Vol. 9. pp. 833—838, 1914.

FACTORY LIGHTING BY HIGH PRESSURE GAS.*

By A. E. BROADBERRY (Tottenham).

At a meeting of the Eastern Counties Gas Managers' Association, a paper on the above subject was read by Mr. A. E. Broadberry, of Tottenham.

In the earlier portion of the paper Mr. Broadberry pointed out the importance of good industrial lighting at the present moment, when so many factories are working at high pressure on Government work.

At the present time, he said, owing to the huge demand for arms, munitions, clothes, and food-stuffs for the war, many factories are working throughout the night as well as during the day.

The efficient lighting of these works, consequently, has become a matter of extreme importance, and experience shows us that the officials having charge are keenly interested in any scheme which will enable them materially to increase the output of work by means of a better lighting of their factory.

That good lighting does increase the output, he added, there can be no shadow of a doubt. It enables men to do their work as quickly, as accurately, and (above all) as cheerfully by night as by day. I have put cheerfulness above all, because I think everyone will admit that there is more tendency to despondency when working at night, and despondency is the worst possible state of mind for producing either speed or correctness in any class of work.

Factories which are at the present time working at night—even taking the district of the Tottenham Company as a criterion—are very varied as regards shape, build, and class of industry, and naturally their requirements in regard to ideal lighting must vary for the same reasons. From the nature of their structure or their work, some require general diffused lighting; but in other trades what is usually known as "point," or "spot," lighting is far more important, if not actually essential.

As an instance of recent high pressure gas installations, Mr. Broadberry mentioned the works of Messrs. Millington & Sons, Ltd., at Tottenham Hale.

The problem to be faced was that, in addition to an area of 39,000 superficial feet for stock-rooms and secondary buildings which had to be lighted at a lower luminosity, a floor area of 51,000 superficial feet, containing a multitude of machines for envelop folding, gumming, printing, ruling, cutting, punching, embossing, type composing, and many other purposes, besides dozens of tables for sorting, labelling, &c., &c., had to be efficiently lighted, and shadows on the work itself had to be avoided as much as possible.

The lamps used consisted of 142 100-candle-power, 299 150-candle-power, 28 300-candle-power, and 10 500-candle-power; the latter being used for lighting the outside of the factory. The tested consumption showed 1,300 cubic feet of gas used per hour, and a consequent cost, at 2s. per thousand cubic feet, of 2s. 7d. per hour for the entire installation, or 0.43d. per thousand candles per hour.

The lamps were so placed as to give the best light on the work. Some photographs were shown illustrating the lighting, but Mr. Broadberry considered that no photograph could do complete justice to the very gratifying result, which must be seen to be properly appreciated. "Indeed, the excellent lighting makes a very striking impression on every visitor; but still more is he surprised when told the low cost per hour for this brilliant lighting. He then readily appreciates that the cost is repaid over and over again by the more efficient work which can be produced with good lighting, as compared with that which is produced with an inferior one."

The lighting effect in foot-candles of surface illumination was tested by the Lumeter, and gave the following results:—

- | | |
|---------------------|----------------------|
| (1) Machine tables, | 5 foot-candles. |
| Do. | do 3.5 foot-candles. |

* Abstract of paper read before the Eastern Counties Gas Managers' Association, April 29, 1915.

This gives an average reading of about 4.5 foot-candles over the whole of the machine tables.

(2) On machines, 4.7, 3.6, and 5.2 foot-candles.

This will give a mean reading of 4.5 foot-candles on all the machines.

(3) Envelope folder and gumming:—

For the sake of comparison, figures were also given for the portion of the factory lighted by electricity.

In passing, it is interesting to observe that in another section of its area the Tottenham Gas Company supplies both electricity and gas; consumers therefore can take their choice, selecting which



FIG. 1.—Messrs. Pentony and Co.'s Factory.

	foot-candles.
Bench	4.5
Shadow—i.e., position where envelopes are counted	1.0
Ruling machines	8.1
Feed side of ruling machine	6.8
Folding Bench	3.8
Litho machine	3.2
Wharfedales	6.8

(4) Compositors' frames:—

The general readings taken in the centre of the lower frames was 8 foot-candles.

Approximately, the height of each lamp from the working plane to the mantle would be 4 feet, but, of course, it would vary as the height of the working surface varied.

illuminant is suitable to the local circumstances.

In the Tottenham district there are many other examples of industrial gas lighting. The following figures in the woollen underclothing factory of Messrs. Sussmann, Ltd., are also interesting. The total floor area is 5,978 superficial feet, and the total candle-power 11,115. Readings for surface illumination are given in the following table:—

	foot-candles.
Sewing Department machines	11.5
Between machines	10.5
Ironing table (directly under 300 c.p. fitting)	15.0
Do. do. do. do. do.	12.5
Half-way between above fittings (distance about 6 feet)	5.5

	foot-candles.
On ironing table between 300 c.p. lamps (about 8 feet 6 inches high)	5.0
Weaving benches	10.5
Directly underneath fitting (150 c.p.) ..	16.5
Do. do. do. do. ..	11.5
Do. do. do. do. ..	16.0
Do. do. do. do. ..	17.0
Between two fittings	13.5
Sewing machines	..

This reading was taken between two lamps approximately 6 ft. 6 in. from ground level.

	foot-candles.
On working parts of looms	8.0
Do. do. do.	7.5
Do. do. do.	8.0
Do. do. do.	7.8
On floor—	
Gangway between rooms	5.5



FIG. 2.—Messrs. Hobson and Sons' Army Clothing Factory.

Needle	7.7
Between two machines	12.5
Random readings taken at second machine table	10.0
Do. do. do. do. do. ..	11.5
Do. do. do. do. do. ..	12.5
Do. do. do. do. do. ..	13.2
Do. do. do. do. do. ..	14.5
Do. do. do. do. do. ..	13.0
Cutting bench (directly under 300 c.p. fitting, about 5 feet from working plane)	7.3
At an angle of about 45°	5.5
Second cutting bench, directly underneath	5.2
At an angle of about 45°	5.5
Weaving rooms and looms—	
On floor	4.5

It will be interesting for members to know that high-pressure gas-irons are used in this factory for pressing the work before packing, and they perform their work to the entire satisfaction of the management.

Fig. 1 shows the lighting of the factory of Messrs. Pentony & Co., where the floor area is 13,000 square feet, and the total candle-power is 19,100. The work carried on in this factory is, among other things, ladies' blouses, ladies' leather belts, gentlemen's ties, portable pails, haversacks, &c.

The readings for surface illumination give the following results:—

	foot-candles.
Eye-letting table (under 150 c.p. decorative fitting)	3.5
Eye-letting table (under 1,000 c.p. suspension lamp)	10.5
Table by eye-letting machine	4.5
Sewing machine	9.0
Do. do.	4.5
Do. do.	8.0
Do. do.	7.5
Needle	4.5
Cutting bench	6.5
Do. do.	10.25
Ironing table	1.8
Do. do.	3.1
Do. do.	2.3
Needle	1.5
Do.	.8
Cutting bench (150 c.p. deep shade)	6.5
Do. do. (150 c.p. flat shade)	4.75
Goffering machine (500 c.p. fitting)	7.5
By goffering bench	4.0

One peculiar feature of these figures is the shading of the lamps with cardboard boxes, on account of the fact that the daylight lighting of the factory is effected by means of the saw-tooth principle of roof. This large surface of glass necessitates the shading of the lights to satisfy present police regulations. Gas-irons are also largely used in this factory.

Among other instances of factory lighting Mr. Broadberry mentioned the Army Clothing Factory of Messrs. Hobson & Sons, in the South Metropolitan Gas District.

The paper was illustrated by a variety of excellent photographs, two of which we are reproducing on pages 200 and 201.

DISCUSSION.

THE PRESIDENT (Mr. W. B. Farquhar) remarked that in Mr. Broadberry's District there were a large number of factories erected, so that he had special opportunities of doing work on a large scale. High pressure gas lighting, however, could also be successful on a small scale and any gas undertaking could give as much satisfaction in one factory, as in half a dozen.

Mr. J. S. Dow said that Mr. Leon Gaster, who had been present earlier in the proceedings by invitation, had unfortunately had to leave before Mr. Broadberry's paper was read. Mr. Gaster had read the paper with interest and he (Mr. Dow) wished to say a few words on his behalf.

As a member of the Departmental Committee on Factory Lighting, Mr. Gaster was naturally interested in data on industrial illumination. At the present time one could not say much about the work of the Committee, but it was hoped that it would be of considerable service in stimulating public interest in this question.

As Mr. Broadberry had pointed out, it was a complex matter to make comparisons between various methods of lighting. One had to take into account other things beside the cost and efficiency of the lamps, such as flexibility and other considerations depending on the nature of the work carried out in a factory. He was glad to see that the author had given a series of figures for the actual illumination on the working plane; this seemed necessary as a basis of comparison as well as the candle-power of the lamps. He would also like to congratulate Mr. Broadberry on the series of photographs shown.

Mr. W. TOWNSEND (Colchester) congratulated Mr. Broadberry on his paper, which was of special interest as showing there were opportunities for lighting, even at the present time.

He would like to know whether any trouble from glare had been experienced with these powerful lights: the illustration seemed to differ in this respect, the lights being more completely shaded in some cases than in others. Another point was flexibility. Had moveable fittings been used with any of those high pressure lamps? At Colchester they had had experience of certain shops with high cranes, above which the lamps had to be fixed. Reliable means of raising and lowering high pressure lamps were therefore desirable.

He could confirm what Mr. Broadberry said as to the importance of good lighting in factories during the present urgent work on munitions of war.

Mr. BROADBERRY, in reply to Mr. Townsend, pointed out that the exposed lights were of relatively small candle-power, mainly 100 and 150 candle units. Lamps were from time to time tested, but in factories it was not practicable to test every individual lamp.

Movable fittings could be obtained, though they were not employed in this case, and there was also available fittings for enabling lamps to be raised or lowered so that cranes could pass.

Mr. Broadberry added that tests of illumination had been made with the "Lumeter" both by natural and artificial light. The latter value did not approach those obtained in bright sunshine.

SCIENCE IN THE DAILY PRESS.*

By PROFESSOR R. A. GREGORY, F.R.A.S.

Judging from statements commonly made in newspapers—not only in daily papers but also in weekly periodicals in which greater accuracy might reasonably be expected—there are few literary people who have a knowledge of natural objects and phenomena equivalent to that of children in the State schools. It is scarcely too much to say that, omitting signed articles written by experts, few newspapers make any announcement relating to a scientific subject without committing a mistake. Either terms are wrongly used, or a matter of common knowledge among men of science is regarded as a remarkable discovery, or observations of a sensational kind are presented to the public as if they were established truths, though they await confirmation from the scientific world, and are mostly unworthy of serious consideration.

It seems to be too much to expect literary people to possess an elementary knowledge of science, or to have any sympathy with scientific precision. but it is not unreasonable to ask for accuracy of description when they are dealing with natural facts and phenomena. They may reply that Shakespeare was often at fault in matters pertaining to natural history; but he at any rate reflected in his works the best knowledge of his time, which is more than can be said of most writers to-day.

We are often told that men of science should cultivate the art of literary expression, but the stronger necessity for

literary men to have at least a nodding acquaintance with the outstanding facts of natural knowledge is overlooked. A well-known author has unkindly said, "The man of science appears to be the only man in the world who has something to say, and he is the only man who does not know how to say it." The retort invited by this remark is that the man of letters frequently has nothing to say, and he says it at great length. The first business of the man of science is to create new knowledge, and not necessarily to clothe his discoveries in a pleasing dress, though he may do so. The facts of science provide material upon which literary art may be exercised, but the two functions of exploration and fine expression are rarely found together.

The methods of accurate observation and cautious interpretation demanded of scientific investigators do not readily lend themselves to attractive description, and the results require more mental concentration to understand them than is usually demanded of a literary performance. A writer of romance can let his imagination have free play, but when natural occurrences enter into the story they should be presented accurately, if the material is to be used rightly. It is the easiest thing in the world to be deceived by appearances, or to accept a belief without inquiry into its foundations; the scientific plan of asking for evidence, and of limiting statements to those for which good justification can be produced, is much more tiresome, yet it is the only way by which truth can be attained; and that after all is the highest aim.

Misconception as to the cause and character of many common phenomena

* Abstract of Paper read before the Circle of Scientific, Technical, and Commercial Journalists, Feb. 23rd, 1915.

in Nature ; the tendency to accept statements without inquiry into the credentials of the author or independent investigation of the facts ; and the view that science is an esoteric study beyond the comprehension of most people, are almost as prevalent now as they were in former times. The book of Nature is open for all to read, yet few look into it and fewer try to understand what is written.

There is a common impression that the conclusions arrived at by men of science are of the nature of beliefs, and have, therefore, no firmer basis than that of conviction. Nothing could be farther from the truth. From his earliest days the student of science is trained to ask for evidence before arriving at a judgment ; and he should hesitate to pass an opinion upon a subject with which he is not familiar. Any beliefs he may hold as to natural phenomena belong to quite a different category from that of knowledge gained by the critical examination of observed facts. No subject is too trivial for inquiry, and no relationship must be regarded as impossible from *a priori* considerations, but the scientific mill must have material to work upon before the value of the product can be estimated. It is permissible to doubt whether the grain is worth grinding, but not to deny it a trial ; for without a test any belief may be held as to its quality. Whether you doubt or believe is of no consequence whatever in scientific things if you cannot give reason for the position you occupy. There must be facts and there must be thought about them before any statement of substantial value can be made as to natural objects and phenomena.

Popular impressions and beliefs relating to weather are often based upon casual observations, and have little foundation in fact. Yet every belief of this kind is worthy of examination, and if it has not been investigated no man of science is justified in asserting that it is untrue. But when such an inquiry has been made, and the evidence has failed to support popular opinion, we cannot do other than state that the case has not been proved. Two such examples may here be given ; one as to alleged change of climate and the other as to a connection between the moon and the weather.

Many people believe that the British climate has undergone considerable changes in comparatively modern times. "The winters (or the summers) are not what they were when I was young," is a statement frequently made ; but when meteorological records are examined, they show that the temperature, rain, snow, frost and like atmospheric phenomena are much the same at the present time as they were in the early days of the declining generation. Going back so far as trustworthy observations with meteorological instruments exist, no evidence can be found to justify the common belief that the climate of England has changed.

Tradition, and general impressions of elderly people, are, indeed, of little value in deciding whether any permanent change of climate has taken place. The only trustworthy test is provided by records of rainfall, temperature or other meteorological observations made systematically with suitable instruments. Such records go back for 150 years or so, and when they are examined critically they are found to give no decided indication of any progressive change, either for the better or worse. From an examination of old records, and of the long series of observations made at Greenwich, Sir John Moore was able to show to the British Association in 1908 that no appreciable change has taken place in the climate of the British Isles during the past six centuries.

The only definite association that can be regarded as established between changes of the moon and weather is that thunderstorms are slightly more frequent near New Moon and the First Quarter than near Full Moon and the Last Quarter ; and it is noteworthy that this is overlooked completely in proverbial philosophy.

So far as earnest investigations have been carried out with the purpose of associating the weather with the various phases and positions of the moon, no connection has been found definite enough to be of service in the actual work of weather prediction.

Many educated people believe that rain follows great battles, the general opinion being that the noise of the guns or the burning of the gunpowder in some way affects the clouds, and causes them to precipitate their moisture. But as the

belief that great battles cause rain was held long before the invention of gunpowder, and is, indeed, mentioned by Plutarch, it is evident that the explanation is unsatisfactory, and only presents an ancient theory in modern terms.

So persistent and widespread is the fallacy, that as recently as the year 1911 a member of the House of Commons asked the First Lord of the Admiralty in Parliament "whether he would arrange for the fleet to carry out their heavy gun-firing practice round the coast at some other period of the year than in the middle of the harvest-time, when the resulting heavy rain may cause serious loss to the farming community." The reply was that "there is no evidence that the firing causes heavy rain," but this only meets belief with denial. Though the argument is not strictly scientific, perhaps the most convincing form of reply to those who profess to believe, or do believe, in the efficacy of gunfiring to produce rain, is to point out that the firing of big guns is carried on at Shoeburyness more frequently than at any other point on the coast, yet the mean rainfall at Shoeburyness, and on the coast of Essex generally, is the lowest in the British Isles.

It is commonly believed that during severe thunderstorms a bolt is sometimes discharged from the clouds and reaches the earth as a solid mass of stone or metal. There is, however, not a particle of material evidence in support of this belief. No thunderbolt originating in the clouds has ever been found, and none exists, whatever conviction may be held to the contrary. What are mistaken for thunderbolts as popularly understood are peculiar mineral objects, meteorites, or particles of soil or rock which have been fused by lightning striking the earth through them.

Almost every newspaper report of a volcanic eruption contains a reference to "flames and smoke" issuing from "the burning mountain," though this description of the phenomena is completely inaccurate. During an eruption there is practically no flame, and certainly none that can be seen except close to the crater; no smoke such as issues from a chimney is ever produced; and there is no burning in the ordinary sense of combustion as in a fire. These elementary

facts have been taught to thousands of school children for the past twenty years, yet popular writers and journalists seem still to be unaware of them.

Uncritical observation and hasty conclusion are responsible for the reports of the occurrence of living frogs and toads enclosed in blocks of coal or other rock, or in clay many feet below the surface of the ground. A stone is being broken by a quarryman, a frog is seen hopping about close to the place, and forthwith the lively imagination of the labourer persuades him that he has seen it actually come out of a cavity in the rock. Dean Buckland made experiments for the purpose of ascertaining how long frogs and toads could live shut up in cavities of stone and excluded from air and food, with the result that most of them were dead within a year, and none survived more than two years. Yet frogs are alleged to have been found enclosed in rocks which, geology teaches, were deposited under water millions of years ago, and afterwards subjected to a pressure which has crushed all the fossils contained in them as flat as paper. If geology is right, the frog stories are utterly incredible. Or, as a distinguished geologist once said, the blow of the hammer that disclosed a live frog inside a block of stone without an opening would at the same time destroy not only geology but the whole fabric of natural science.

Writers in the popular press, and in technical papers also, frequently indulge in cheap sneers at what they call "scientific theory." In their minds, the man of science lives in a world far removed from the realities of life, and knows little of material things or practical possibilities. Nothing could be more incorrect than this view. With the exception of pure mathematics and metaphysics, every branch of physical and natural science depends for its progress upon practical work in the laboratory or the field. No one appreciates the value of experimental work more than the man of science, and no one is more critical of scientific theory. Whenever a theory is put forward in any scientific society, it is always subjected to severe attack from people most competent to point out its weaknesses; and in any case it only

survives until someone brings forward evidence which completely disproves it.

The public likes to believe that men of science predicted from theory that this or that thing was impossible which was afterwards achieved; and its literary guides usually associate a great discovery not with the man whose work in the laboratory or study led to it, but to the man who made a commercial success of it. It was the mathematical work of Clerk Maxwell and the scientific experiments of Hertz which produced wireless telegraphy, but to the popular press the only man responsible for this wonderful discovery is Mr. Marconi.

Very soon after Hertz had described his remarkable researches on the production and detection of electro-magnetic waves, the scientific world realised their importance. It was pointed out that as Hertzian waves possess the property of passing through fog or material obstacles they could be used for a system of wireless telegraphy.

The receiver used by Hertz was not suitable for telegraphic work, but a more practicable form was soon found, and was used in a lecture delivered by Sir Oliver Lodge before the Royal Institution in 1894, when the statement was made that the apparatus would respond to signals at a distance of half a mile. Two years later, Mr. Marconi filed a provisional specification of apparatus for signalling by means of electric waves.

Mr. Marconi not only saw that the laboratory experiments of Hertz might be put to practical use, but also proceeded to adapt them to a system of telegraphy through the ether. To his knowledge, confidence and daring must be ascribed the commercial development of wireless telegraphy, but his achievements were direct consequences of the scientific work of Hertz, Maxwell, Faraday and Henry. As he himself acknowledged in 1900:—

“The experimental proof of Hertz, thirteen years ago, of the identity of light and electricity, and the knowledge of how to produce, and how to detect, these ether-waves, the existence of which had been so far unknown, made possible wireless telegraphy.”

When Wilbur and Orville Wright commenced their experiments in artificial flight, the only exact experiments they

could find as to the resistance of the air to machines driven at different velocities were those made by the man of science, S. P. Langley. They were the pioneers of sustained flight with aeroplanes, and they have acknowledged that their confidence in the practical solution of the problem was derived from Langley and his work. They said:—

“The knowledge that the head of the most prominent scientific institution of America believed in the possibility of human flight was one of the influences that led us to undertake the preliminary investigations that preceded our active work. He recommended to us the books which enabled us to form sane ideas at the outset. It was a helping hand at a critical time, and we shall always be grateful.”

It is constantly stated that artificial flight would have been accomplished long before if engines light enough to drive them had been available, but that is not the case. Flights with two, three or more passengers show that lightness of the motor is not the only consideration, and motors with equivalent weights were available ten years before the Wrights designed their man-carrying aeroplanes. It was by following the scientific guidance of Langley, and using mechanical ingenuity to extend it, that they were able to give practical effect to the desire of man to rise above the clouds.

In these and all related matters our guides and counsellors, not only in the periodical press, but also in less ephemeral publications, are, in the great majority of cases, unaware of the most obvious facts and phenomena of Nature, and have no acquaintance with the most elementary vocabulary of science, or outlines of scientific discovery. In everything that relates to the material universe around them, they are blind leaders of the blind; and they call their darkness light. They are indifferent to the wonderful growth and extent of scientific knowledge, and live in a paradise in which rounded phrases and curious fancies are of more importance than actual facts. In such a world a one-eyed man can be king. A more enlightened view will only be obtained when it is realised that an educated man must know something of science as well as of literature.

DISCUSSION.

The Chairman (Mr. Leon Gaster), in opening the discussion, pointed out the importance of this subject to the Circle.

Among those who took part in the discussion of Professor Gregory's paper were Mr. H. G. Wells, the well-known novelist, Mr. Chambers Smith (*Sanitary Record*), Mr. G. Rentell (*Electricity*), Mr. Ross (*Times Engineering Supplement*), Mr. Warrilow (*Electrician*), and Mr. H. Oakley.

It was pointed out that the standpoint of a daily newspaper in regard to such items was somewhat different from that of a purely scientific or technical journal. Some already made use of special expert writers on engineering subjects and in general they welcomed the co-operation of authorities in dealing with articles of special technical nature.

Some instances of errors in articles dealing

with the use of electricity and gas were given, for example, a case in which "unaccounted for gas" was confused with "gas leakage."

Several speakers pointed out that the Circle, having amongst its members representatives of so many different technical journals, might be of assistance to the section of the daily press, which was not already provided with a staff of technical experts.

A resolution was subsequently passed welcoming this form of co-operation with the daily press. The suggestion was also made that articles of a scientific or technical nature should preferably be signed by a responsible journalist; or, if anonymous, should preferably be referred to a reader having a special knowledge of the subject. It was resolved that members of the Circle should be approached with a view to the preparation of a list of scientific, technical and commercial journalists prepared to act in this capacity.

TRADE JOURNALISTS AND THE BOARD OF TRADE.

At a subsequent meeting of the Circle of Scientific, Technical, and Commercial Journalists on March 23rd, the relations of trade journalists to the Board of Trade were discussed. The President of the Institute and other members of the Executive were present by special invitation, and members of the Circle representing a great variety of industries attended the meeting.

A paper was read by Mr. Charles H. Luke on "The Reorganisation of the Board of Trade and the British Consular Service." Mr. Luke gave some interesting figures for the exports of this country which had increased remarkably since 1870, but still to a far less extent than the corresponding trade in Germany. He suggested that in view of the importance of the interest involved the duties of the Board of Trade should be divided among three Ministries—namely, a Ministry of Commerce, a Ministry of Railways, and a Ministry of Labour. Mr. Luke also criticised the present system of nomination of the Commercial Attachés and Consuls, who, he suggested, should be British subjects.*

The Chairman (Mr. Leon Gaster) in opening the discussion referred to a very important blue book on the subject issued last year.† This contained some most useful information, and showed also that there were many diverse points to be considered, and that the question was a most complicated one. All would

agree as to the importance of taking the present opportunity to organise our industries on more scientific lines.

Mr. Wilfred Stokes, representing the British Engineers' Association, said he had been working hard to get the Government to take up a scheme for the reorganisation of the Board of Trade. His plan, in outline, was to have a highly specialised and well-paid Board of Industry, with a President; a Council of fifteen or sixteen adequately remunerated members, representing our largest industries. Then there should be a number of qualified Trade Commissioners and attachés in our dependencies and Colonies. The cost would amount to a small sum in comparison with our present turnover, and ought very quickly to be recouped many times over in the increased trade such arrangements would undoubtedly bring about.*

In the discussion that followed Mr. S. J. Sewell mentioned that forty-eight hours after war broke out, he and a few other trade journalists had approached the Board of Trade and offered their assistance, but so far no definite action had been taken. Other speakers dealt with problems arising in the industries they represented, and the difficulties that had been encountered in securing the co-operation of the Authorities. Finally, it was agreed that Mr. Gardiner, the President of the Institute of Journalists, should be asked to approach the Board of Trade with a view to bringing about some form of co-operation with technical journalists. After discussion it was resolved to place in the hands of the Executive Committee in order to decide what further action should be taken.

* See "The War and the Parting of the Ways," by Charles Luke (Sampson, Low, Marston & Co., Ltd.)

† See Fifth Report of the Royal Commission on the Civil Service (1914).

* See "How to Pay for the War," by Wilfred Stokes issued by the British Engineers' Association.

VISIBILITY: ITS PRACTICAL ASPECTS.

NOTES ON A DISCUSSION OPENED BY MR. C. C. PATERSON AND MR. B. P. DUDGING AT A MEETING OF THE ILLUMINATING ENGINEERING SOCIETY, AT THE HOUSE OF THE ROYAL SOCIETY OF ARTS (18, JOHN STREET, ADELPHI, W.C.), AT 8 P.M., ON TUESDAY, APRIL 27TH.

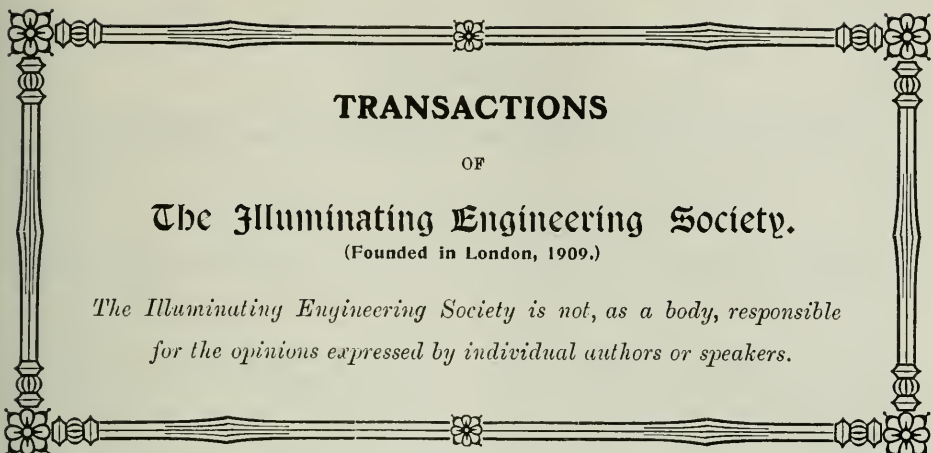
Visibility depends, *first*, on the behaviour of the human eye and on the personal impressions of the observer; *secondly*, on the manner in which the object is illuminated; *thirdly*, on the nature of the object viewed and its background. The consideration of visibility, therefore, affects many problems in daily life, and the subject is of interest to the physicist, the physiologist, and the lighting engineer.

The following are some of the suggested points to be dealt with in the discussion :—

- (1) The visibility of objects in close proximity to bright lights.
- (2) The effect on the appearance of distant objects of (A) the colour of the objects themselves, (B) the colour of the light by which they are illuminated.
- (3) The effect of contrast and the influence of the surroundings on the visibility of an object.
- (4) The relative visibility of objects by direct and indirect light.
- (5) The relative visibility of objects by natural and artificial light.
- (6) The visibility of distant lights at night (coast lights, railway signals, illuminated signs, &c.).
- (7) The visibility of objects illuminated by the beam of a searchlight or motor-car headlight.
- (8) The connection between illumination and acuteness of vision and the conditions of visibility of strong and weak light.

ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

The Ninth Annual Convention of the Illuminating Engineering Society in the United States will be held at the New Willard Hotel, Washington, September 20th—23rd inclusive. The Chairman of the Convention Committee is Mr. E. S. Marlow, of the Potomac Electric Power Company.



TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

VISIBILITY ; ITS PRACTICAL ASPECTS.

Proceedings at the meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, April 27th, 1915.

A Meeting of the Society took place on Tuesday, April 27th, Mr. J. HERBERT PARSONS, M.B., D.Sc., F.R.C.S., being in the chair.

The Minutes of the last meeting having been taken as read, the Hon. Secretary read out the names of new applicants for membership as follows :—

Child, J. S.	The Edison & Swan United Electric Light Co., Ltd., Ponders End, Middlesex.
Elliott, J. W.	The Edison & Swan United Electric Light Co., Ltd., Ponders' End, Middlesex.

The names of applicants announced at the previous meeting on March 16th,* were read again, and these gentlemen were formally declared members.

The Chairman then called upon Mr. C. C. PATERSON to read the introductory paper by himself and Mr. B. P. DUDDING, entitled "**Visibility, its Practical Aspects,**" and the following took part in the ensuing discussion :—

Mr. A. P. TROTTER, Dr. W. J. W. ETTLES, Mr. S. D. CHALMERS, Mr. HAYDN T. HARRISON, Dr. F. W. EDWARDS GREEN, Dr. W. WATSON, Mr. J. S. DOW, and Mr. P. J. WALDRAM.

Mr. PATERSON briefly replied, and THE CHAIRMAN called for a cordial vote of thanks to the authors of the paper.

In conclusion THE CHAIRMAN announced that the **Annual Meeting** of the Society would take place on **Tuesday, May 18th**. After the transaction of the formal business there would be a discussion on "**Some points in connection with the Lighting of Rifle Ranges.**"

* *Illum. Eng.*, Lond., April, 1915, p. 161.

VISIBILITY.

Notes on Some Practical Aspects of the Question.

BY CLIFFORD C. PATERSON AND B. P. DUDDING.

Introduction to Discussion at the Meeting of The Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m., on Tuesday, April 27th, 1915.

THE term visibility is used here in its broadest sense, viz., the ability to see an object or part of an object. We are accustomed to distinguish with more or less facility the objects which we look at each day, and as a rule, if our sight is not seriously defective, our seeing suffices for all practical purposes. We, therefore, are generally content to regard visibility as one of those phenomena which require little investigation and we devote attention to the provision of sufficient illumination to put the question of good seeing beyond doubt. It is only in certain circumstances when the illumination is necessarily low, or our power to distinguish objects is interfered with that it becomes necessary to examine some of the phenomena on which visibility depends.

Our opening of a discussion on this subject will take the form of an account of inquiries which we have made at different times into conditions which in some practical cases prevented good visibility.

These inquiries deal with some very different aspects of the question, and are in some cases, very incomplete. The reason is that the experiments described were not always undertaken with a view to a complete research on the subject in question, but merely to elucidate certain points which had a bearing on other work. We admit, therefore, a certain element of discursiveness and incompleteness and hope that some of the many omissions will be filled by others who take part in the discussion.

A particularly interesting aspect of the question of visibility on which unfortunately we have no experimental data is the art of rendering distant objects

invisible by appropriate colouring and marking. The authors were once informed that if a donkey and a zebra were located in a distant field (and remained there to be observed) the zebra would become invisible long before the donkey. This effect was discussed in an interesting article by Col. F. N. Maude in "Land and Water" for January 30th, in which he gave an incident from practical experience of a regiment with pipeclayed belts and accoutrements being invisible by the side of another regiment which had equipment of a more uniform nature.

The following are some of the practical questions which have engaged our attention and which are dealt with below:—

(1) The visibility of distant lights at night.

(2) The visibility of objects illuminated by the beam of a searchlight or motor headlight.

(3) The visibility of objects in close proximity to bright lights.

(4) The relative visibility of objects by direct and indirect light.

(1) THE VISIBILITY OF DISTANT LIGHTS AT NIGHT.

Sailors and railwaymen have constantly to "pick up" and distinguish at night very small point sources of light. The visibility of such lights is often exceedingly low, particularly at sea. The lights may be white (yellow) red or green, and are necessarily exceedingly faint at the distances at which they have to be picked up. The white masthead light carried only by steam vessels is supposed to be visible at 5 miles, and the red and green side lights which are carried by all vessels, have to be visible

at 2 miles. The latter requirement under practical conditions can only just be met with oil burners, and the result is that if one ship is two miles away from another the respective lights are on the limit of visibility. We had occasion a few years ago to carry out an investigation* into the visibility of such point sources of light, and it was found that a definite value of visibility for practical use was 1.6 candles at 2 sea miles viewed on an ordinarily clear dark night. We further found that the inverse square law held rigidly for point sources of light when there was no atmospheric absorption, so that 1.6 candles at 2 sea miles looks the same as 0.000,000,12 candle at one meter. The apparatus we used was sensitive to + or - 5 per cent. and on an ordinary clear night no atmospheric absorption could be detected at distances of 2 miles.

Still considering point sources of light it was found that the intrinsic brilliancy of the source had no influence on visibility but that it is only the total flux of light emitted which counts. If we take two sources of light subtending less than one minute of arc, one of them one-sixteenth-inch diameter and the other approximately 1-inch diameter both having the same candle-power, they will both appear equally visible point sources from a distance of say 100 yards. When, however, a source of light or an object becomes large and subtends an angle which is appreciably greater than that which corresponds with the resolving power of the eye, the laws given above must no longer be assumed to hold.

Now the equivalent of 1.6 candles at 2 miles is not the smallest light it is possible to see under favourable laboratory conditions when the eyes are thoroughly dark adapted. If the light intensity is lowered to about one-quarter or one-fifth of this it may still be seen, at least intermittently, but the resulting value is on the threshold of visibility by direct vision. It is interesting then to try to estimate quite roughly what is the amount of energy which thus seems to be the

minimum which will stimulate a single element of the central part of the human retina.

This may be calculated from a knowledge of the shape of the sensitivity curve of the eye at different wave lengths and the average distribution throughout the spectrum. For radiations to which the retina is most sensitive, viz., between 0.52 and 0.58 μ and for a pupil aperture of 7.5 mm. the amount of energy per second from a point source which will just stimulate direct vision when the eyes are dark adapted we find to be of the order of 10^{-15} watt.

An idea of the magnitude of this fraction of a watt may be obtained if we assume the distance from the earth to the sun to represent a watt. Then the amount of energy per second which will stimulate vision is represented by a distance of about two millimetres.

In what has been said earlier we have been thinking mainly of white light. Some interesting phenomena are revealed when the faint sources of light are coloured, particularly in relation to oblique vision. A green light will appear some five times brighter when viewed obliquely than when viewed directly, but a red light acts in exactly the opposite way. If we place a point source of green light in a dark room so that its visibility from the position viewed is equivalent to about 0.01 micro-candle at a meter, an observer will pick this light up when he is looking in some other direction and be quite conscious of its presence, but no sooner does he look towards it than it is gone. A faint red light on the other hand cannot be picked up by oblique vision at all, but when an observer has finally discovered it by direct vision he is impressed by how very visible it is. If he glances to one side however it disappears. The colour of faint lights is not distinguishable by oblique vision.

A very faint point source of white light is picked up more easily by oblique than by direct vision but the difference is not so marked as with green light.

(2) THE VISIBILITY OF ILLUMINATED OBJECTS AT NIGHT.

This aspect of the question calls for attention particularly in the use of search-lights and motor headlights. What, for

* Paterson & Dudding, Measurements and Notes on the Visibility of Point Sources of Light. Proc. Phys. Society, London, Vol. XXIV, Oct. 1912. Proc. Optical Convention, 1912.

example, governs the visibility of a man walking along the road and being overtaken by a car? One often hears of the rating of headlights by the "length of the beam," but no definition has been suggested, as far as we are aware, which fixes the point at which a beam may be said to end. If the man on the road may be said to be visible at a certain distance what candle-power must there be to make him visible at twice that distance? Certainly more than 4 times because the man himself appears much smaller at twice the distance.

In order to obtain preliminary data on these points we made some experiments on a stright road bounded by trees and shrubs. Objects on the road were seen against a thick shrubbery in the distance so that for a person in dark clothes there was a minimum of contrast.

One way of making observations is to direct the beam of light down the road and cause persons clad in differently coloured clothes to walk away from or towards the light until they are pronounced to be just visible by persons behind the headlight viewing them against the dark background. This was done in a number of cases, with the following results:—

TABLE I.

Person observed.	Distance at which he was discerned (in feet).	Illumination produced by headlight at this point in foot-candles.	Surface brightness of person observed.
A	215	0.09	0.001 ₂
B	253	0.05 ₆	0.001 ₉
C	260	0.04 ₆	0.002 ₀
D	265	0.05 ₆	0.004 ₀
E	365	0.02 ₄	0.004 ₀
F	470	0.01 ₃	0.003 ₅
G	610	0.008 ₁	0.005 ₅

It will be found from this table that except for observations D and E the surface brightness of a person divided by the distance is approximately a constant.

The results, however, obtained by such an experiment as this are necessarily

somewhat indefinite and limited in scope, since the criterion used is not a good one, *i.e.*, the vanishing point of an object, and further there was a considerable variation between the projected areas of the different persons observed as viewed in elevation. An additional disturbing element was the presence of the motor headlight beam, which caused an intense illumination of the road in the foreground.

To place the measurements on a more fundamental basis the object itself was made luminous and the headlight beam eliminated altogether. We arranged a kind of sentry box on wheels, the open side of which was covered in by a mask. This mask was cut out in a form which had roughly the shape of a man, and translucent paper stretched across it. A number of small lamps were placed inside the box and fed from cells, the lamps being so arranged that they rendered the paper mask luminous. A pair of wires ran the whole length of the stretch of road with the ends connected to rheostats, at the point where the observers were located. By connecting these wires and rheostats in series with the lamps inside the box they could be dimmed down at will by the observers, and the brightness of the luminous object adjusted to any desired degree. Altogether the apparatus when used in the open on a dark night had rather the appearance of an alternately appearing and disappearing churchyard ghost. It was found again that the vanishing point was not a very definite criterion and that it would be better to fix up a "comparison object with which equality of visibility of the test object could be established at different distances. In the final arrangement (shown in Fig. 1), therefore, the brightness of the test object was adjusted until it appeared as visible as the comparison object. This comparison was made in a series of experiments with varying conditions. In one series the luminous object was wheeled to different distances from the observer, and a series of masks was used to vary its actual size, so that at each position the solid angle subtended by the object at the eye was the same. In this test where the area of the retinal image remained the same, constant visibility

was found when the brightness of the object was constant.

The above experiment was repeated but instead of using a self-luminous object, the object was illuminated by a headlight lamp and observed from behind the lamp. Under these conditions it was found that for the same sized object to be equally visible at the same distance its brightness had to be somewhat higher than when it was self-luminous. This increase of brightness required may be due to a change in the adaptation of the eye, and possibly to the change in the contrast between the object and the road.

It will be at once noticed that the observed readings so plotted distribute themselves about two straight lines. The sudden change in the slope of the curve occurs when the object viewed subtends an angle of about 10 minutes of arc. The experiments previously described on point sources of light showed that below the resolving power of the eye the visibility depends on the total candle-power, *i.e.*, the intrinsic brightness $\times$ area. For constant visibility, therefore, at a given distance, if we halve the area, we must double the intrinsic brightness. This is the condition that will be found to hold over the

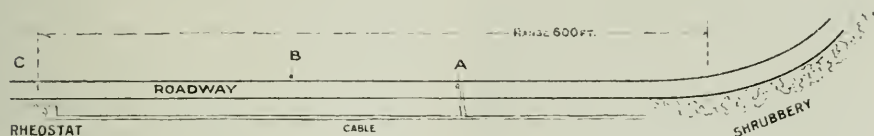


FIG. 1.—Arrangement of experiment on the visibility of objects at night.

A. Movable test object illuminated internally by electric lamps.
B. Comparison object (fixed). C. Observer.

In another experiment, the distance of the object from the observer was kept constant, but its dimensions were varied, keeping, however, the same shape, thus changing the size of the retinal image. This is equivalent, as far as the retina is concerned, to moving the same object to different distances, but it had the advantage of keeping the object in the same relation to the background against which it was viewed.

In this experiment the comparison of the object with the standard for equal visibility entailed the comparison of objects of different apparent size, but this was not found to be very difficult if the visibility of the comparison object was kept sufficiently low. The tests were repeated over a still wider range of size of object in the laboratory, and these are perhaps the most interesting of the series. The results are shown graphically in Fig. 2 where the log. of the linear dimensions and the log. of the brightness of the object at equal visibility are plotted.

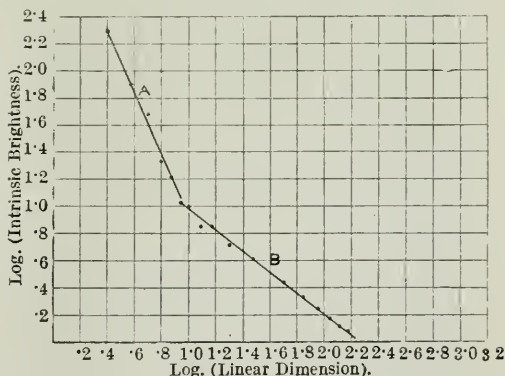


FIG. 2.—Curves showing the connection between linear dimension and intrinsic brightness of an object for constant visibility at a given distance.

Section A. Intrinsic brightness $\times$ (linear dimension)² = constant.

Section B. Intrinsic brightness $\times$ linear dimension = constant.

line A in Fig. 2 which is the part of the curve which deals with smaller objects. The portion B of the curve is for objects well above the resolving power of the eye* and our observations seem to show a different law connecting dimensions and brightness for constant visibility for such objects. The mean of several series of observations indicates that for constant visibility at a given distance if the area of the object is halved the brightness has not to be doubled but increased in proportion to $\sqrt{2}$.

We are therefore led to the following conclusion regarding visibility and distance that for an object subtending an angle less than about ten minutes of arc (about 1 foot at 100 yards), the brightness for equal visibility must be proportional to the square of the distance from the observer, but for objects subtending larger angles than this the brightness for equal visibility must be proportional simply to the distance between the object and the observer.

In putting forward this result we have to point out that it is not in accordance with the usual assumption,† but we have not been able to ascertain on what experimental work the usual hypothesis is based. This hypothesis is that the square law condition governing the visibility of small objects holds also for large ones. Blondel in a recent publication also discredits this ordinary hypothesis in connection with searchlights, and develops a connection between the brightness required to discriminate detail and the distance away of the observed object based on a theory of visual acuity.

Accepting then the results and conclusions we have outlined above we are able to see how the useful range of motor headlights increases with increasing intensity of the beam. It will be generally agreed that under the conditions of use of motor car headlights it is the larger size of objects which have to be discerned, i.e., those appertaining to curve B.

If now a headlight enables an object to be discerned at 100 yards, by how much must the intensity of its beam be increased to enable the same object to be seen at 200 yards? For equal ease of discerning the obstacle at twice the distance, we have seen that the brightness of such obstacle need not be more than doubled, and to produce double the brightness at double the distance the intensity of the headlight beam must be increased 2×2^2 , i.e. 8 times.

This may be stated generally as follows: The useful range of a motor car headlight is proportional to the cube root of the intensity of its beam.

It may be noted that on the usual assumption this multiplier would be 16, but our experiments only indicate such a large factor when the smaller class of objects is under consideration.

We have not experimented with searchlights over the greater distances with which they deal, but we see no reason why the above conclusions should not be valid so far as they apply to the problem.

(3) VISIBILITY IN THE PRESENCE OF BRIGHT SOURCES OF LIGHT.

This is merely the much discussed subject of glare, upon which a great deal has been written and a certain amount of experimental work carried out. What follows is not intended to be a general survey of the subject but merely some notes and experiments on one phase of it. Reference to the existing literature and data is not therefore contemplated. The original object was to obtain a criterion by means of which the interference with visibility caused by a bright lateral light could be measured. Two cases were under consideration:—

(1) The ability to see past an approaching car with bright headlights, (2) the interference with visibility when working in ordinary illuminations with a "light in one's eyes."

The upshot of the experiments was to show that with the very low illumination, prevailing at night and the consequent dark adapted condition of the eyes lights of the projector type very much less intense than motor headlights, are sufficient to render it impossible to distinguish any objects at all which are situated behind them. This result was not unex-

* The resolving power of the eye as a whole is generally assumed to be of the order of one minute of arc, but it is not a very definite quantity.

† Nerz. Searchlights: Their Theory, Construction and Application. Chapter 4.

pected, but we were surprised to find from a number of tests made under (2) with the intention of measuring the diminution of visibility of objects with an equivalent surface brightness of about 2 foot-candles and upwards under severe conditions of glare, that it was difficult to find any diminution of visibility at all. There is no doubt about the annoyance caused to an observer by the presence of bright lights in his field of view, but it appears that his ability to distinguish objects or detail is only affected when the brightness of such objects is relatively low. An effective demonstration of this is to arrange a white surface close to a bright lamp which can be switched on or off at will without affecting the illumination at the surface. This surface is illuminated by two sources, a central area being screened from one of them, thus producing a shadow. This contrast between the brightnesses of these two portions can be made as great or small as desired by regulating the position of the lamps, and the absolute brightness can also be varied at will. As the distinction of detail is largely a matter of discriminating small differences of shade, the glaring light, if it affects discrimination of detail, might be expected to prevent the observer distinguishing between the two areas when their brightnesses are nearly the same. As a matter of fact, a shadow contrast of 5% at an absolute illumination of 2 foot-candles was entirely unaffected by a glaring light of 20 candles placed 8 inches from it when viewed from a distance of 6 feet.

If, however, the equivalent surface brightness be reduced to 0.5 foot-candles the contrast was entirely obliterated under the severe conditions of the experiment.

Again, the following reading test was carried out by three observers. A page of ordinary printed matter was arranged with a constant illumination of 2 foot-candles at its surface, the lamp producing the illumination being placed close to the page and at a distance of 2 inches from one side of it. This light could be shielded from the eyes at will without changing the illumination at the printed surface. The time was noted which was required by each observer to read aloud, and as quickly as possible, one-half the page of

printed matter when the light from the lamp was shining into his eyes, and then the time to read the second half with the eyes shielded from direct light. This was done with several pages of printed matter, with the following mean result:—

Observer.	Mean time of reading one page	
	With glaring light.	Without glaring light
A	238 secs.	239 secs.
B	281 secs.	269 secs.
C	259 secs.	287 secs.

It was only when the illumination was reduced very much below 2-foot candles or when the ground work of the printed page had a dark tint that detail tended to become obliterated.

These results do not affect the question of the undesirability of glaring lights from other points of view but merely indicate that it is not easy to discover that glaring lights have very much effect on the visibility of detail under ordinary conditions of lighting.

It is not without interest to note that the value of equivalent surface brightness at which the diminution of visibility due to a glaring light begins to occur in these experiments corresponds with the value at which Koenig and Brodhun showed that Fechner's Fraction ceases to be a constant.*

(4) VISIBILITY OF DETAIL BY DIRECT AND INDIRECT LIGHT.

The discrimination of detail in certain circumstances depends almost entirely either on shadow or on the direction of the incident light. Where the surface of an object to be viewed is uneven but uniform in colour, the only way in which the unevennesses can be shown up is by differences in the illumination of such surfaces caused by the different angles which they present to the incident light. If the unevennesses are very deep they will be shown up by the shadows which are thrown by the raised portions on to the surrounding surfaces. For instance the embossed lettering used on some

* Bell. "The Art of Illumination," page 5.

notepaper depends entirely on this action, and a sculpture in bas relief must obviously present a very different appearance according as it is illuminated by unidirectional light at glancing incidence or by light from a large source striking it mainly at normal incidence.

This question has a wide practical application in the manipulation of self-toned fabrics, viz., unicoloured fabrics with no natural contrasts. A person doing needlework with such materials depends for the discrimination of the detailed strands of the fabric on the small shadows cast by one strand on to the next and on the varying brightness over the curved surfaces of each individual strand. Both of these factors depend on the unidirectional character of the

light incident on the material and the inefficiency of thoroughly diffused, viz., indirect light for such work is most marked. One of the authors has for upwards of ten years used indirect lighting for domestic use, and for a long time he ridiculed the often repeated assertion which was made that it was a most unsatisfactory light by which to do needlework and particularly darning. He has come to see, however, after experiment, that the contention is perfectly sound and that there is nothing so good as a unidirectional light giving harsh shadows for the discrimination of detail in needlework of all kinds. Indirect lighting with its soft shadows is in our opinion an ideal light for domestic use except in respect to this one particular.

DISCUSSION.

Mr. A. P. TROTTER said that the help of oculists was needed to explain the physiological side of many of the subjects discussed by the Society, and that was particularly the case in the present instance. Engineers probably rarely attended meeting of ophthalmologists, but ophthalmic experts were very welcome to the meetings of this Society. He fully agreed with the authors about the disadvantages of indirect illumination. It always needed to be helped out with other lights. He had made some experiments in connection with the effect of a glaring side light on visual acuity. He expected to find that if the light was not too strong, acuity might be improved owing to the reduction of the size of the pupil. But he had come to the same conclusion as the authors, namely, that within limits no effect was produced. He was surprised that the accurate measurements of the authors had not discovered an appreciable absorption of light by the atmosphere.

The conditions of vision under extremely feeble illumination were interesting. He had not experimented with point sources but with large surfaces. He had to review a book on "N" rays, and he repeated the conditions laid down, with certain modifications and additions. One of these was to use one eye at a time. He found that after staring for many minutes at a feebly lighted screen, waves

of darkness would appear to move across, more or less periodically as in the stereoscopic experiment with after-images described by Dr. Chunder Boés. The appearance of the screen was instantly altered by any sudden movement of the body and he could quite understand how willing pupils of an imaginative teacher might deceive themselves.

The work by the authors in connection with ships' lights was most interesting and important, and had been conducted with an excellent mixture of practical conditions with scientific method.

Dr. W. J. W. ETTLES: The notes on visibility to which we have just listened are very helpful and suggestive, because they are founded on a series of practical observations carefully recorded and any hypotheses applied to them can therefore be distinguished as such from the actual facts themselves, and can be weighed by those who approach the facts from different standpoints. It would occupy far more time than your courteous attention could be asked to extend, to traverse all the issues raised: hence I will only deal with one or two, and that in the spirit of helpfulness requested, and not by way of destructive criticism.

First then as touching the question of the threshold of visibility of distant lights at night. The contributors have made a point in their endeavour to

express this in terms of a unit of energy, viz., a watt. This is very useful because it brings out a point on which I have often insisted. This energy can only evoke sensation on the assumption that the space or emitted cone is re-collected to a proper apex on a percipient organ. Now, as a matter of fact, that seldom can obtain, if only by reason of the chromatic defects of our own eyes. In a quite normal eye the red rays are brought to a focus on the retina, but the blue rays cross in front and form a diffusion circle. As soon as the energy is diffused it falls below the stimulation point, and the source of light is not perceived. That is one reason why the green light is better seen; it is seen better because as soon as you get sufficient energy in the cone base to perceive it as green you have a relatively much larger colour area than is the case with the apex point of red. But I hasten to add that this is only one of the factors at work. Apart from its chromatic defects, the eye may have optical or refractive defects and both eyes may not be the same. Now a very small error of refraction will produce a great diffusion of a point, and its watt energy for stimulating a single cone in that area is therefore lost. Take the case of a man normal in one eye, and only very slightly short-sighted with the other. He will see a light as a point with one, and a disc with the other. As that light gets farther away the point energy of the disc will be too low, and he will see the light with the normal eye only. This is why a man with two good eyes has twice the perceiving power at extreme limits of vision, and why the Navy insists that each eye shall be perfect. The energy entering the sense organs is simply doubled. But remember this is only true of the limit of visual perception and not of degrees of luminosity, which can give rise to sensation over retinal cone areas of the diffusion circle.

Next, I will say a word about coloured point sources. The result of the experiment is that there is high sensitiveness for a small central area for red light with blindness of the periphery of the field; while with green light there is lowered central sensitiveness and largely increased perception over an extensive periphery.

That is quite true. A "minimum visible" red can only be seen over an angular field of 20° , *i.e.*, 10° each side of the fixation line. Outside this it simply disappears, not only as red, but it disappears as a luminous point. Green is badly seen centrally, but peripherally it greatly increases in brightness, and can be seen in all parts of the field, *but*, and this is important, it cannot be seen as green. The actual area of colour perception is very small—quite as small as red. The real difference is that while red is blotted out altogether as a luminous point, green persists. The great restriction of our field for red is well seen in twilight, *e.g.*, the Volunteer Training Corps red brassard cannot be seen on a black coat in the evening. Again the greatly increased stimulus value of green is shown in the spectrum. If you close the slit down to the limit of perception, or if you project the spectrum on black velvet you will find that the most luminous portion is not now in the neighbourhood of the D line (0.58), but has shifted to that of the E line (0.53).

As to the limit of form perception, it has long been known to astronomers that binary stars could not be seen by the naked eye as discrete, unless their angle of separation was at least one minute. We know that vision depends on the stimulation of a retinal cone, and that a cone (foveal) is 0.002 m.m. in diameter. What is the size of the retinal area subtended by an angle of one minute? All rays cross in the eye so that we have two cones apex to apex at the nodal point.

Let X be the crossing point.

The distance of X from the retina is 15 m.m. Then

$$\frac{2\pi R}{360 \times 60} = \text{the retinal area, or}$$

$$\frac{2 \times 15 \times \pi}{360 \times 60} = 0.004 \text{ m.m.}$$

i.e., the image corresponds to two cones. But if this is so we cannot have a visual acuity higher than one minute. On the other hand many persons, sailors, savages, hunters, &c., have extraordinary visual acuity. I know one man who can put down on a chart the bullet marks

on a card at a miniature rifle range of 65 feet. This vision must be represented by at least 2, if 1 be taken as normal vision. I think it is not a question of focus, for the man with $V=1$ and the man with $V=2$ may each be normal, but it is a question of the fineness of the foveal cones. Hence it is, too, that birds of prey have such extraordinary sight—their retinal elements are so slender.

Finally, I will touch on head-lights and searchlights, from the point of view of the person subjected to the glare. We have many factors, but some of the principal are these:—

1. Greatly increased sensitiveness. A match struck in a picture theatre will affect your seeing the picture for some time. Out of doors it is not noticed (in daytime). That is the same thing as adaptation. The sensitiveness to faint differences in luminosity means a vastly greater sensitiveness to great stimuli, so that they become blinding.

2. The positive scotoma or negative after image. If you have glanced for an instant at the sun you will have noticed the persistence for many minutes of a black or coloured after image. If the glance has been prolonged you may have it for hours, and if it has been foolishly prolonged there may be so-called "eclipse blindness" which may be permanent. This positive blind area projected in the field renders us insensitive to faint stimuli, and is a powerful factor in the annoyance and helplessness caused by glaring light.

3. We have irradiation. The retinal elements are all closely united, and stimuli overflow so that over-stimulation of one awakens its neighbours, and we think the object is larger. That is why an electric lamp filament is so much thicker when it is alight, why a heliograph mirror of 3 inches seems nearer 3 feet if you catch the flash at close quarters, and why, while visual acuity rises with illumination to a certain point, the irradiation causes such encroachment on the image that its detail is lost if the illumination is carried too far.

4. We have internal reflections. A veil of light from the various internal surfaces of the eye which covers, as with a light chaos, and so drowns the feeble emissions of the surrounding objects.

MR. CHALMERS said he was interested in the paper presented by Messrs. Pater-son and Dudding, because of its relation to the question of visual acuity under reduced illumination.

In considering this problem he had come to the conclusion that the visual acuity depended at higher illuminations on complex optical conditions, but that a value was soon reached at which the visual acuity depended primarily on the quantity of light which was sent to the eye from each element.

To obtain normal visual acuity from each element of the Snellen chart it is necessary that each square minute of the chart should be observed, so that as the visual acuity decreases we can only identify elements which are larger and larger; as the illumination decreases we find that the total quantity of light which is required to show each element gradually decreases.

Tschernerg quotes results by Dinalt which show that the quantity of light from the element gradually decreases until, when the element is between 10 and 20 square minutes, the quantity of light reaches a minimum value which corresponds to $\frac{.47}{\pi} \times \frac{1}{(3400)^2}$ candles $= .014 \times 10^{-6}$ candles, at 1 metre. This value compares with the values given in the paper for the least visible source.

The corresponding value calculated from the data of Koenig is 10^{-6} candles.

This seemed to indicate that a minimum quantity of light was required from each element, and that the element was of the order of from 10 to 20 square minutes in area.

He (Mr. Chalmers) therefore decided to investigate the question of the size of this element by noting at what illuminations elements of various sizes could be seen by direct vision with an eye adapted to darkness by avoidance of all bright lights, and arrangements are being made for the experiments. Among the questions he wished to investigate was whether the quantity of light would again increase as the element increased in accordance with Dinalt's figures, or continue to fall off as in Koenig's results.

These measurements have not yet been carried out; but the results given in Table II. of the paper are of interest in

this connection. If these results are confirmed in later measurements it would seem that the explanation is that the effects of light falling on the different elements of the eye are not strictly cumulative in their effects. Perhaps an electric analogy would indicate the effects to be expected.

If the energy were received by a group of thermo junctions, each connected to its own circuit. If each thermo junction received an amount of energy U per sec. the temperature would rise and a voltage of $E = \frac{U}{k}$ would result.

The current in the circuit would be $C = \frac{E}{R}$, R being the resistance, and the energy would be $EC = \frac{U^2}{kR}$.

If now energy U_2 were distributed over a number n^2 of these thermo junctions, each circuit would have a voltage.

$$E = \frac{U_2}{n^2 \cdot k}$$

and the final energy transmitted by each circuit would be

$$\frac{U_2^2}{n^4 \cdot kR}$$

and the total by all the circuits would be

$$\frac{U_2^2}{n^2 \cdot kR}$$

so that in order to produce the same effect it would be necessary to have

$$\frac{U_2^2}{n^2} = U^2, \text{ or } U_2 = nU.$$

In other words, the *total quantity* of energy required would vary as the linear dimensions of the receiving area or the illumination would vary inversely as the linear dimensions.

This result is not in accordance with Koenig's observations, but seems to be in accord with Messrs. Paterson and Dudding's observations.

It is interesting in this connection to calculate the amount of energy which corresponds to the threshold as given by Aubert's determination. He finds that a sheet of white paper is just visible when illuminated by a candle at 200 to 250 metres.

Aubert's measurements of threshold give value = $\left(\frac{1}{200}\right)^2$ candles at 1 metre.

The quantity of light reaching the eye from each sq. minute of object is—

$$\frac{.25 \cdot 10^{-4}}{\pi} \times \frac{1}{(3400)^2} \times \frac{\pi \times 9}{10^6} \times \frac{.1}{4\pi} \times T \text{ joules,}$$

where the pupil diameter is assumed to be 6 mm. T is the unit time assumed = .1 sec.

$$\frac{.25 \cdot 10^{-4}}{\pi} \times \frac{1}{1.15 \cdot 10^7} \times \frac{\pi \times 9}{10^6} \times \frac{.1}{4\pi} \times .1 \times 10^7 \text{ ergs}$$

$$= .16 \times 10^{-12} \text{ ergs}$$

this compares with Planck's quantum of energy $h\nu = 3.9 \cdot 10^{-12}$ approx., giving $h\nu$ for an area = 24 sq. minutes.

In view of the very rough nature of the approximations for pupil diameter and still more for T , this is in agreement with the idea that for the threshold a quantity of energy equal to Planck's quantum must reach each element of the retina.

TABLE.

Dinalt, illum. in metre- candles.	Acuity.	Square minutes.	Product 1 and 3 × .9 refl. coeff.
Large	1.50	.44	—
16.7	1.25	.64	9.6
1.5	1.0	1.	1.35
0.67	.75	1.78	1.07
.25	.50	4.00	.90
.12	.37	7.1	.77
.047	.3	11.1	.47
.028	.21	22.7	.57
.020	.15	44.4	.80
.016	.075	177.7	2.56

In connection with the questions raised by Dr. Ettles, Mr. Chalmers pointed out that the question of diffraction had to be taken into account in considering the visual acuity in cases of high illumination; that the receiving mechanism of the eye was capable of distinguishing very small angles was shown by the phenomena of stereoscopic vision. We had authentic observations showing that the eye could detect which of two objects was the nearer when the difference in the convergence angles was 5 or even 3 seconds. The eye must be able to appreciate these minute differences between the impressions re-

ceived by the two eyes. The explanation might be that when the images were not exactly similarly disposed to the cones the effect could be appreciated perhaps as a difference of light value and the muscular effort, to bring the two images to exact coincidence, appreciated. The effect was, however, a special one, and not ordinary seeing.

In connection with the observations on glare he would point out that for limited times and by special effort the eyes were able to overcome difficulties and see much more than usual. All trained observers appreciated this fact, but the eye was not capable of going on for long periods seeing those differences which were beyond easy vision, and unless observers were prepared to say that no evil effects in the way of earlier fatigue took place, the experiment would lose its value.

MR. HAYDN T. HARRISON said that he was surprised to note that at the commencement the authors had defined "visibility" as "the ability to see an object." But it was obvious from their subsequent remarks that the term was interpreted in its correct sense, namely, the capability of an object of being seen.

This might not be considered an important point, but in fact it was. The term "illumination," for instance, is independent of vision, so the term "visibility" is independent of individual vision, and it was for this reason he was glad to note the average of several observers had been taken.

The term "dark adapted" was a new term, but it meant a very great deal. He himself had become dark adapted for certain experiments he desired to carry out, by going to sleep in the room in which he was going to carry out his investigations and waking up with the room darkened to the degree in which the experiments were to be carried out. With regard to the authors tests on the road, he rather judged that they decided the vanishing point by allowing the object to recede from the observer. He could not help thinking that if they had done exactly the opposite, and noted when the object became visible, the results would have differed because if one looked at an object receding one retained a mental picture for quite an

appreciable period, whereas in the case of an object approaching you this was not so. The authors' tests on the effect of glare were very important. There had been a good deal of talk about glare, but this he believed was one of the first occasions at which an actual practical statement had been put forward as to when glare did affect the vision and when it did not, and he was glad to know that it did not really cause any serious effect when the surrounding illumination was above a certain degree. This was an effect he had always been inclined to believe because practically the only places in which there was any serious glare were cases of low illumination such as at night in streets where the general illumination was extremely low and in consequence the glare from street lamps and vehicles became very great. The point made in the paper as to the reliance placed upon shadows for seeing certain classes of objects of a monochromatic nature is much more important than many illuminating engineers realise.

This particularly applies to textile factories, workrooms and workshops.

DR. EDRIDGE-GREEN said the question of an object being visible or not depended on the relative difference between the dark and light parts, a point which seemed to be generally overlooked. He had carried out experiments with a convex mirror, projecting various lights upon it of different sizes. He projected red, green, or blue, and then estimated how the light appeared. At certain distances it was found that the lights became white. The red was the most difficult, but when sufficiently small it became white when viewed with the central portion of the eye. The same thing occurred with the periphery of the retina. The small faint red light soon became invisible, whilst as the luminosity was increased it became red, and by increasing it sufficiently it appears red to the extreme periphery of the field of vision.

The periphery only of the retina was relatively colour blind. It was continually and erroneously stated that the Purkinje phenomenon was not found with the centre of the retina, though there were many who stated quite correctly that it was. If it were not found with

the centre of the retina a red which was of equal brightness with a blue in ordinary daylight would still appear similar when viewed centrally in a dim light, but the most casual observation would show that the red became darker than the blue when viewed with any part of the retina.

He had experimented with a hole in a door in which he fixed a blue glass and a red glass. By moving a lamp behind the glasses he was able to ascertain that, when it was close to the door, the red glass was brightest for all parts of the eye. When the lamp was moved away from the door so as to diminish the luminosity of the two glasses in equal proportion a point was reached when the red glass still appeared brightest for the centre of the eye, but the blue glass was the brightest directly the eye was moved a little outwards. When the lamp was moved still further away the blue glass appeared brightest for all parts of the eye, including the centre, but the difference became still more marked when viewed with the periphery of the eye. This might possibly explain the varying results obtained by different observers.

A simple experiment which proves conclusively that the photo-chemical stimulus is external to the cones may be made as follows. On arising in the morning arrange a mirror so that the sun is reflected from its surface, then whilst one eye is closed and covered with the hand, the other eye is opened and closed so that the image of the sun is visible for a fraction of a second: both eyes being now



FIG. 1.

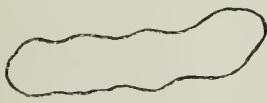


FIG. 2.

closed and covered with the hands, a clear cut after-image of the sun is seen on a dark background (Fig. 1). It will be noticed that there is nothing else visible in the field of vision. If the head be now moved rather sharply to one side the after-image will be drawn out into a long sausage-shaped form with irregular knobs on it (Fig. 2).

If the head be sharply jerked we can obtain several after-images, plainly showing that the photo-chemical stimulus is

movable in the retina, and therefore cannot be situated in the cones. I find these experiments succeed best in the morning immediately after sleep, probably because the processes of the pigment cells are retracted. If any reader find that he cannot see any of the subjective phenomena described by Purkinje or me, I would suggest that he select one of the most accurate observers of his acquaintance and ask him to repeat the experiment, without giving him the least clue as to what he is to see. If he describe the phenomenon as I have described it, it is obvious that we have obtained important confirmatory evidence. I find that whilst many older men fail to see various subjective phenomena they are rarely missed by the young.

Dr. W. WATSON said he had, during the last year or two, been making observations on the threshold of vision for different people. These experiments had a bearing on the question of the comparative visibility of point sources at the centre and periphery of the eye. He had been rather surprised to find that although the majority of people would agree with the authors of the paper, viz., that apparently the threshold for central region of the retina was much higher than the surrounding parts, yet there were a number of people in which this was not the case.

The authors' tests on motor lamps interested him because a few years ago he assisted in carrying out a number of tests on various motor car headlights. In that case he was studying the illumination produced by motor car headlights at different distances and attempted to determine the distance and the cross-section of the region at a given distance at which a given object was visible. He had, however, finally to fall back on photometry. It would be interesting to compare the range of such motor car headlights as were used in those days. Only white lights were then used, but the use of coloured lights was a problem of some practical interest at the present time. In the trenches they desired a method of illumination, and from experiments he had made he was fairly certain that coloured lights would give a good

effect under the conditions there, where everybody's eyes were perfectly dark adapted.

He was not quite clear, however, that coloured lights would give such a good effect in slightly foggy weather. It was generally agreed that the use of a yellow beam was an advantage in a motor car headlight or projectors in foggy weather and in some cases yellow glass was put in the field of the beam, whilst in others it had been proposed for use in the reflector.

On theoretical grounds, and as far as he could judge on practical grounds, the use of such a yellow beam might be an advantage. It was not so much that a yellow light or a red light in itself enabled one to see the object better. But most of the difficulty in seeing with a dark-adapted eye in a weak light arose from the fact that the sensitiveness of the periphery parts of the retina increased by many thousand-fold, and these peripheral parts were particularly sensitive to the blue end of the spectrum. When using a strong source of light in fog, a lot of light came back towards the eye, and that white light produced a sense of glare. If, however, we used a light which was weak in blue rays, the effect of this glare was very considerably reduced. In practice he found that a convenient way was to wear canary coloured glasses, and another way out of it might be to have a strip of ruby red glass across the top of the wind screen, the idea being to look through this on to the headlights of an approaching motor car. In this way one would not destroy one's dark adaptation in any great measure.

Mr. J. S. Dow remarked that the conditions affecting visibility in a feeble light were quite distinct from those prevailing at high illuminations. In the latter case the apparent brightness of an object seemed to be independent of distance, within limits. But in a feeble illumination the impression received by the eye seemed to depend on the total amount of light radiated from an object, and not only on its intrinsic brightness.

He could confirm, from his experience, what Mr. Paterson said as to the appearance of faint coloured lights by direct and oblique vision. It had often struck

him that these phenomena might account for apparent inconsistency in evidence regarding the appearance of ships' lights at sea.

The appearance of small distant coloured objects, such as uniforms, seems to be affected by a number of different factors, *e.g.* the fact that a different part of the retina was utilised according as the object was near or far away; the contrast with the object's surroundings; and the effect of non-achromatism of the eye in "spreading" distant blue and violet. A soldier in a greyish-blue uniform possibly faded into the landscape, not only because of the small contrast, but also because the blue element could not be focused and appeared hazy. Another fact, pointed out by Prof. Blondel, was that the conditions of visibility in twilight might be reversed. Owing to the Purkinje effect a grey-blue uniform appeared almost white, but a red coat black in the night time. In a dark wood the scientific grey-blue uniform would probably be the more easily seen of the two. The effect of striping and spotting surfaces seemed to be to break the line of division and divide a large object into a series of small masses. He had heard it said that the striped colouring of the tiger was contrived by Nature to make the animal difficult to distinguish amidst the vertical lines of the jungle grass, whereas the spot of the panther (which climbed trees) had a similar effect amidst "dotty" foliage. He was told that chessboard marking of objects to render them indistinguishable dated back to Nelson's time, and was still known as "Nelson's checker."

It was interesting to note that there were two practicable methods of rendering objects indistinguishable. One method was to paint them to resemble the tone and colour of the objects in their neighbourhood (*e.g.* hulls of ships, hydroplanes, etc., might be painted grey): another possible method was to utilise mirror-surfaces by means of which the surroundings were automatically reflected towards a hostile observer. At the present time the study of these points seemed to be a very important one from the military standpoint. The utility of aeroplanes and submarines as scouts depends to a great extent on their escaping detection, so

that any researches which would result in progress in this respect would be well repaid.

Mr. Paterson's experiments on the visibility of objects on dark roads were most ingenious. At the present time there seemed to be a very pressing need for some method of defining the point at which a motor-car head-light became "powerful." He had heard of officers on leave, unaccustomed to the present regulations, being fined in one district because their lights were too bright, and in an adjacent district because they were not bright enough. It had been suggested that lights giving a "30-yard beam" were considered permissible. But who could say what such a definition meant? Physically there is no termination to a beam and practically only a gradual transition from brightness to darkness—a transition, moreover, which depends very much on the state of the atmosphere.

It would be very useful if some simple and definite test could be prescribed to be applied to confirm a personal opinion that the lights were too bright after the car had been stopped. Might not an electric torch equipped with a grease-spot or Leeson disc be used as a photometer-gauge for the purpose? Having decided the permissible brightness of lights, the photometer-gauge could be adjusted so that the spot vanished in the illumination obtained at a distance of say thirty feet from the car. Such a device would surely be a better test than personal impression, and might be an aid to the authorities in dealing with what was admittedly a difficult subject.

Mr. P. J. WALDRAM, speaking with reference to the motor-car headlight, said that the task of the constable was very difficult. If a motor-car were moving fast, the only thing to do was to measure the distance of certain objects in the road, and as the car passed see if these were illuminated at a distance of 100 yards, and ascertain by that means the length of the beam. If the car were stopped a good rough test was to walk across the path of the beam at a distance of 50 yards, and if one's boots and clothing were not distinctly illuminated the motorist might be generally allowed to proceed.

There was not the slightest doubt that, particularly in the present darkened streets, a glaring motor-car headlight was, if not a source of danger, at any rate a source of great profanity to every driver it passed. It would appear, however, that the acuity of ordinary persons at night had been sensibly increased since the war. Things which they could not see when the streets were well illuminated were now easily discerned. That had been borne out by inquiries of constables who had been many years in the force. As to the checker pattern, he would suggest that the reason why this tended to make objects disappear was that at any considerable distance a checker pattern tended to prevent the eye from seeing the shape of the object. He had noticed frequently in outpost work that when viewing cows and men together, even against fresh green grass, if the cows had white spots or stripes it was exceedingly difficult to find out even with glasses whether one were looking at a man or a cow, and soldiers of many years' experience had confirmed him in this. He understood that the object of the extremely irregular checker patterns which were applied to the sides of forts and redoubts, and similar things, was to make a mass of smudges of colour, so that at any considerable distance the eye could not form any definite outline and see what the exact object was. One must not conclude, however, that decided patterns like pipeclayed belts or the red trousers of the French infantry were always an unmixed blessing. There were certain states of the atmosphere when a piece of red in a uniform stood out in a most particularly glaring fashion; whereas, at other times, perhaps only a few minutes earlier or later, that same red might cause the whole uniform to disappear.

Mr. JOHN DARCH (*communicated*):—In the third part of Messrs. Paterson and Dudding's paper dealing with visibility in the presence of bright and exposed sources of light, the authors conclude that "it is not easy to discover that glaring lights have very much effect on the visibility of detail under ordinary conditions of lighting." Indeed, the

authors have tabulated results which show that there is practically none.

There are two weaknesses in this conclusion :—

1. The mere test of time in reading a printed page is of little value unless the expenditure of energy and eye-strain are taken into account. One of the observers actually read quicker (which might be taken to mean easier) in the face of a glaring light than when it was shielded, which shows nothing more than that there was a greater expenditure of effort. Two friends may travel together, the one on a smooth footway, the other on a rough road : because they occupy equal time one cannot reasonably conclude that the rough road is as easy and good to walk on as the paved footway, or that it makes no difference to shoe-leather ; nor, if he on the rough road arrived first that the rough road was, therefore, easier and better to walk on than the footway. That represents the value of the time reading test. The broad fact remains that visibility is not only greatly impeded but is often rendered impossible in the face of a bright light, while eye trouble is the natural penalty for foolhardiness. Unfortunately, there is a reactionary class of mind in some lighting engineer, and architects that will eagerly seize upon such an insufficiently qualified statement as that to which I have taken exceptions in order to justify the obtrusive display of lights which characterise their lighting schemes.

2. The second weakness in the conclusion above referred to lies in the meaning of the words "ordinary conditions of lighting," and yet the authors state that their conclusions do not apply to an illumination of less than 2 foot-candles. Two foot-candles cannot be considered the lowest limit of ordinary lighting ; we may have this amount under a table lamp, but 1 foot-candle is thought by many to be quite brilliant for ordinary purposes and the average is less. The authors' conclusions, therefore, are likely to be misapplied, particularly by those who have a hazy notion of the luminous intensity of a foot-candle. But, again, the intensity of the illumination may go for nothing, for 10 foot-candles to a person working on black material or striving to distinguish detail in dark

walls, pictures, &c., is less than 1 foot-candle to those engaged on white subjects, and in such cases the shielding of a light immensely improves visibility.

Visibility is the *raison d'être* of the art of illumination : it is the kernel of the whole question, the only proper objective of the lighting engineer. It is not what can be made visible under sustained effort, but how the objects of daily life can be seen and fully appreciated with the same ease and pleasure that one experiences in open daylight or on the stage of a theatre.

Mr. J. G. CLARK (*communicated*) :—Time did not permit me to make a few remarks on Messrs. Patterson and Dudding's paper at the meeting on the 27th instant ; I would therefore like to submit a few observations in writing.

I was extremely interested in the experiments which indicated the effect of glare upon visibility. The conclusions drawn from them by the authors are that the presence of naked lights do not materially affect visibility for illuminations above 2·0 foot-candles. This conclusion is confirmed by inquiries I have made at different times regarding the personal experience of workmen. I have found them sometimes working with a unit of about 60 candle-power just above and a little in front of their foreheads. They did not seem to mind it.

There can, however, be no question of the discomfort that is produced by bright naked lights in or near the field of vision. This is admitted by the authors. I am constrained to think, however, that this discomfort would in turn lead to impaired visual power if the exposure to the naked light were prolonged, say, half an hour or more. I do not see any statement in the paper of the period of exposure during the experiments recorded in Table II., but from practical experience I strongly believe that the "time-factor" is an important one and as it is one which invariably exists in practical work, it is worthy of careful consideration.

It might be (and I think probably is) a fact that whereas bright naked lights near the field of vision do not affect visual power the discomfort and fatigue following on exposure for, say, half an hour or more would indirectly reduce the visual value of a given degree of illumin-

ation. Perhaps the authors can throw some light on this aspect of the question of glare.

I was glad to see the question of direct *versus* indirect lighting dealt with although there are still some aspects of the question that need elucidation.

In a paper read before the Society by Mr. V. H. Mackinney and myself, the effect of an extension of the area of the luminous source upon the shadows produced by it was dealt with. It was shown experimentally how the size of the shadow of a given object extends as the area of the source increases until, when the source becomes of infinite area, the shadow becomes invisible, not because it has disappeared but because it has spread itself everywhere: it may be described as "shadowful" not "shadowless." Further, not only is the size of the shadow increased but the *contrast* between adjacent parts of the surface containing the shadow decreases (see page 137, *THE ILLUMINATING ENGINEER*, 1913), and as it is this *contrast* which gives definition to the shadow it would follow that "visibility" which depends on light and shade is greater with "direct" than with "indirect" methods. An illustration of the effect of contrast in its relation to visibility can be seen in the military flat-crowned cap. The conspicuousness of this seems to be entirely due to the *sharp contrast* in the illumination of the crown as compared with the other parts and the background. When the crown is rounded or dome-shaped it does not appear nearly such a good target as when flat, although the amount of illumination may be just the same or even more. Presumably the explanation is that the illumination on the rounded cap is graded and is therefore rendered less visible by the absence of sharp contrast.

Visibility by shadow contrast exists in many factories and workshops, and for this reason I am glad it has engaged the authors' attention.

There is, however, another aspect, namely, the visibility of written or printed matter. From observations I have made visibility by shadow contrast seems to have no practical significance here, and for this reason I have come to regard "indirect" and "direct" lighting

as of equal value for reading and writing purposes, that is, 3 foot-candles (say) of indirect illumination is equal to 3 foot-candles of direct illumination provided the eye does not wander from the working or reading surface. If the eye does wander it encounters in the case of "indirect" lighting the bright surfaces of the walls and ceiling, which seem to that extent to reduce the visual value of the illumination of the working surface when the eye returns to it.

It seems, therefore, from an industrial and commercial point of view that the great loss of light that is occasioned by indirect methods is unjustified.

The "softness"—that is, lack of sharp shadow contrast—of indirect lighting makes it very pleasant for use in art studies, and in fact in any place where its softness is appreciated. The loss of light in such cases becomes of secondary importance.

The CHAIRMAN (Mr. J. Herbert Parsons) congratulated the Society on the excellent paper of Messrs. Paterson and Dudding, and on the very interesting discussion which had resulted from it. The question of the visibility of point sources of light was one of great importance and Mr. Paterson's work had been of great use to a recent Committee of the Board of Trade on Sight Tests for the Mercantile Marine.

The subject was of still greater importance at the present moment. He was surprised to hear that there was no appreciable absorption at 2 miles on a clear night. He believed that Mr. Paterson's minimum energy determination agreed fairly well with previous observations by Eyster and Boswell. Owing to physiological variability of sensitiveness absolutely concordant results could not be expected. The disturbing effect of bright lights in the field of vision and the visibility of detail by direct and indirect light had been attracting much attention from the industrial point of view before the war broke out. He would like to remind them of the excellent work of Cobb in America on the former topic. There were many points in the discussion which he would like to refer to and in some cases criticise.

The Authors' reply (*communicated*): We desire to express our pleasure that the discussion which we have initiated has led to so many interesting and helpful contributions to our knowledge of the subject of Visibility. We have also to thank those who joined in it for the kind treatment which they accorded to the very incomplete notes with which the discussion was opened.

We are specially interested in Mr. Chalmers' valuable contribution and to find in it a theoretical confirmation of the change we have found in the visibility law when the object has appreciable dimensions. We hope he will develop further and publish the details of the work outlined by him in this discussion.

Several of the points raised by Drs. Edridge Green and Ettles are too physiological in character for us to feel able to express definite opinions on them.

With regard to the first point raised by Dr. Ettles, it is, we think, necessary to remember that the image of a point source of light can hardly remain stationary on any one cone, but must be moving about rapidly over a number of cones, never, however, covering more than one at any instant. The eye in some way, however, sends to the brain an impression of a single point source, and if so there might be ground for supposing that a point source slightly out of focus would cause the same integrated stimulation as one that was in focus.

When considering the question of visual acuity it should be borne in mind as Dr. Watson implied, that it is not a physical problem only, and that cases of extraordinary acuity might be ascribed to psychological causes.

In reply to Mr. Harrison, we did actually make observations with persons approaching the car light as well as while receding from it. This should have been made clearer in our notes of the experiment. As regards the use of the term "dark adapted" this is the name given to a phenomenon well-known to all workers on the eye, and has been used in literature on physiological optics for some while. The phenomenon, however, is one, the importance of which is not, we think, sufficiently appreciated by many illuminating engineers at the present time.

We note with interest that Dr. Watson

has examined persons, the foveal portions of whose eyes are more sensitive to faint white lights than the peripheral portions. This is certainly abnormal and it would be interesting to know if the colour vision of these people was otherwise normal.

Both Mr. Dow and Mr. Waldram referred to the effect produced by colouring objects in irregular chequer patterns. We would suggest that if objects having the same overall surface brightness are viewed against a background having a surface brightness not very different from that of the objects, then the object with an irregularly chequered surface would be the less visible, but that the same does not necessarily hold when the contrast in colour or surface brightness is more marked.

We agree with Dr. Dow that it is very important to have a definite criterion when stipulating the permissible strength of motor car headlight beams.

Both Mr. Clark and Mr. Darch, together with Mr. Chalmers point out that we omit all mention of fatigue after prolonged work under glaring conditions. In our remarks we stated that we sought a physical method of readily measuring diminution of visibility due to "glare," and indicate the lines on which the experiments were made, showing that we were not successful in obtaining such physical measure. The question of eye fatigue should certainly be taken into consideration in any comprehensive work on glare and we admit the incompleteness of our experiments in this respect. Eye fatigue is a physiological and psychological phenomenon and not at all easily measured in physical quantities.

We cannot accept Mr. Darch's contention that because an observer read slightly more quickly with the glaring light it necessarily follows that he used more effort. The difference in the time of reading with and without the glaring light was only that which would be observed when reading different pages of matter under the same conditions of lighting.

We have more sympathy with the latter portion of his contribution and should be sorry if our notes on this subject encouraged in any way the use of offensive systems where strong lights are located in the field of vision.

SHORT NOTES
ON
ILLUMINATING ENGINEERING.

LIGHTING OF STATUES AND MONUMENTS.



Washington Monument (Baltimore).



Francis Scott Key Monument (Baltimore).

In a recent article in the *Electrical Review and Western Electrician* F. M. Weller gives some photographs showing spectacular lighting at the Star Spangled Banner Celebration, which took place at Baltimore last September.

Some of the decorations took the form of festoons of lamps hung across the streets, but the two illustrations show a

method which deserves to be more generally used on such occasions, namely, the use of concealed lamps to illuminate national monuments. The photograph confirms the practicability of the method, and it could easily be applied (in less troubled times than those prevailing at the moment) to such monuments as the Queen Victoria Memorial, near Buckingham Palace.

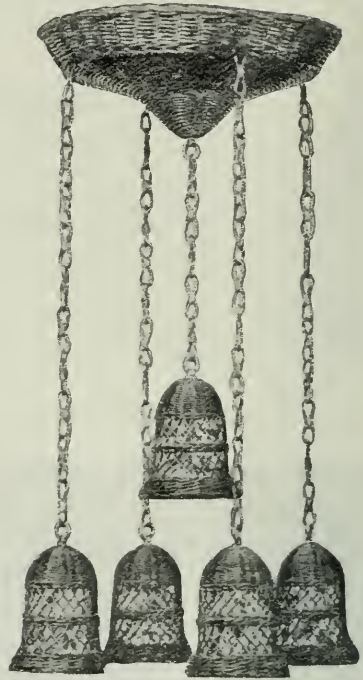
REED-WARE LIGHTING FIXTURES.

The illustrations show a novel form of a lighting unit which has been developed in the United States.* These Reed-Ware fittings are made in the shape of portable lamps, brackets, and chandeliers, &c., and even "indirect" bowls. They are naturally intended for sunny and unconventional rooms, porches, &c., and one would imagine that they would be specially useful for emergency lighting in garden fêtes, &c.

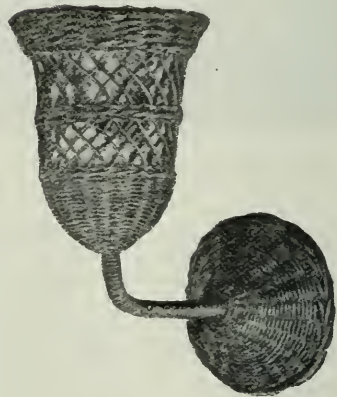
WHITEWASHED KERBS.

According to the *Star* an interesting expedient is to be used in London with a view to diminishing the inconveniences of reduced public lighting. The Commissioner of Police is asking local authorities to whiten the street kerbs, thus enabling the line of demarcation between pavement and roadway to be more readily distinguished by drivers of vehicles and pedestrians. Experiments are said to have proved the utility of this device, which one can quite well believe. For the main element in this case is *contrast*. Everyone knows that the danger of stumbling over a step is accentuated when its tone and colour are approximately the same as the surroundings. A well-whitened doorstep is undoubtedly safest.

* *Electrical Review and Western Electrician*, October 17th, 1914.



Reed-Ware Chandelier.



Reed-Ware Bracket Lamp.

Reed-Ware Fittings.



TOPICAL AND INDUSTRIAL SECTION.



[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]



SINGLE LAMP REFLECTORS FOR SHOP-WINDOW LIGHTING.

In the January issue of *THE ILLUMINATING ENGINEER* reference was made to the increased "fillip" to concealed shop window lighting given by the restrictions imposed by the war.

We have just received from the **General Electric Co., Ltd.**, particulars of a new series of reflectors to be used with single lamps, which are claimed to be a great advance on the older less scientific types.

These reflectors effectually screen the lamp from the eyes of people looking into the window. The variety of shapes enables all sorts of problems to be tackled. Special features are the accessibility of the carrier ring holding the reflector in position, and the provision (in deep conical and parabolic patterns) for the necessary ventilation.

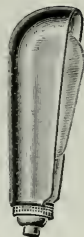
We understand that this effort at standardisation is attributable to the General Electric Company's Illuminating Engineering Department, who may be freely consulted on all problems in connection with shop lighting.



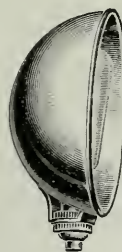
Shell.



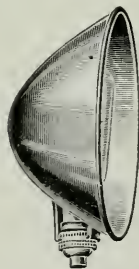
Fluted Scoop.



Plain Scoop.



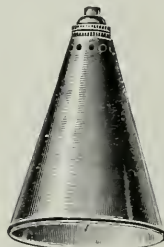
Hemispherical.



Horizontal Parabolic.



Vertical Parabolic.



Conic.

HALF-WATT LAMPS AT SELFRIDGE'S.



Photo., by artificial light, of a corner of the Provision Department (ground floor) at Selfridge's, where the B.T.H. "Eye-Rest" System of indirect lighting with "Half-watt" lamps has been installed.

An interesting recent installation of "half-watt" or gas-fitted lamps has been carried out at Selfridge's by **The British Thomson-Houston Co., Ltd.**, from whom we have received the illustrations accompanying this note.

Owing to the brilliancy of these lamps, good shading is an essential point. The intrinsic brightness of the filament is said to be no less than eight times that of the ordinary metal filament lamp. This fact, and also the relatively high efficiency of these gas-filled lamps, encourages their use with indirect and semi-direct fittings, and these appliances have been installed

on a considerable scale at Selfridge's (Oxford Street) in the new annexe.

The "Eye-Rest" system is installed on the ground floor and the first floor of this large block of buildings, and the effect is shown in the pleasing illustrations—reproduced, we are informed, from photographs taken entirely by artificial light.

The installation reflects credit on those concerned, the B.T.H. Illuminating Engineering Department, the contractors Messrs. Rashleigh, Phipps & Co., and on Mr. H. J. Clarke, who is in charge of Messrs. Selfridge's Building and Equipment Department. It is well worth a visit.

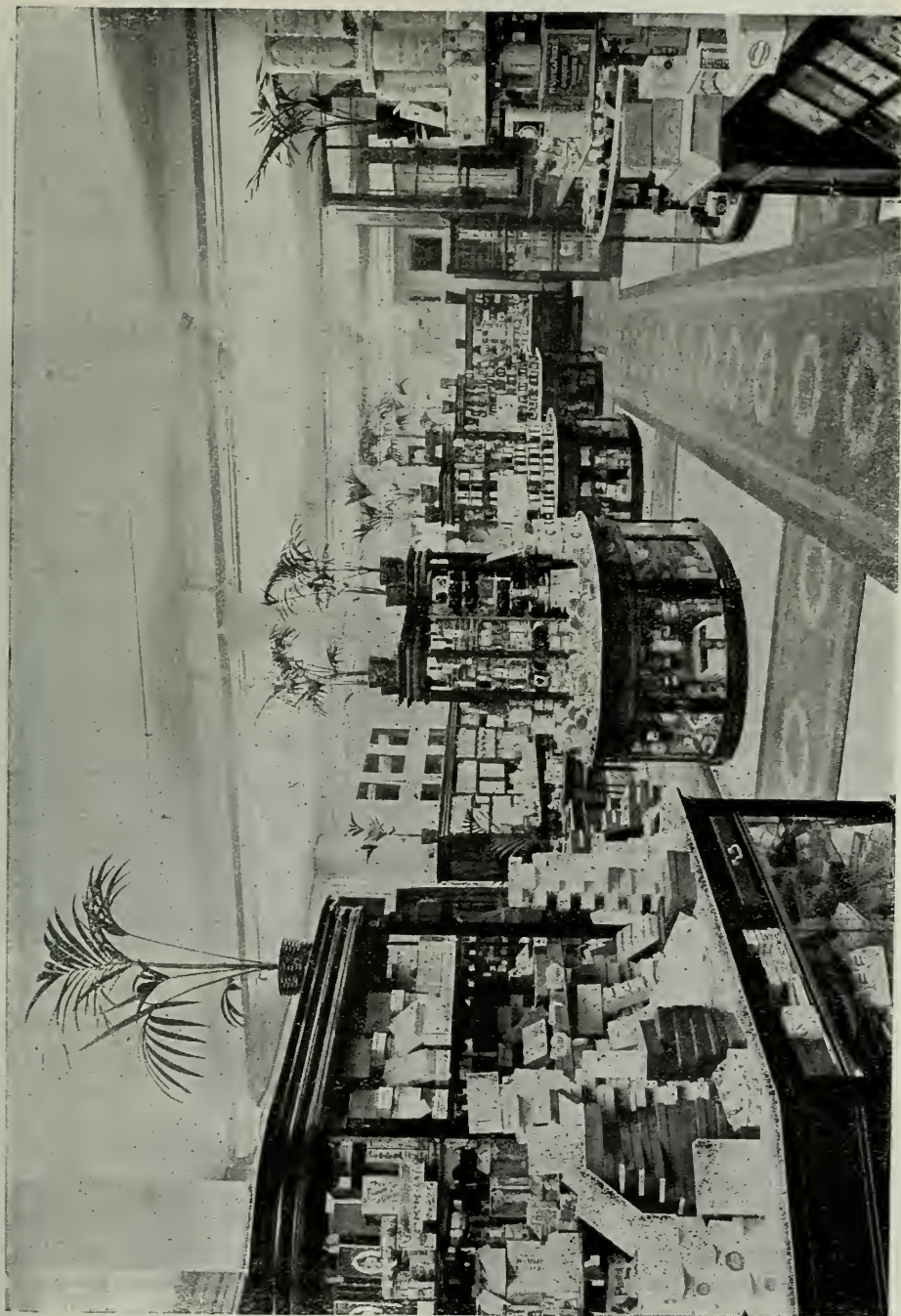


Photo. by artificial light, of a corner of the Grocery Department at Selfridge's (first floor), where the B.T.H. "Eye-Rest" system of lighting with "Half-watt" lamps has been installed.

A SECTION OF THE SHOWROOMS OF THE TOTTENHAM AND DISTRICT LIGHT, HEAT AND POWER COMPANY.

The two photographs accompanying this note were recently taken at the showrooms of the Tottenham and District Light, Heat and Power Company in the High Road, Tottenham. The exposure was made simply by the light of the lamps used for the ordinary lighting, and was arranged with a view to giving a correct representation of the ordinary conditions of illumination.

Fig. 1 shows a portion of the imposing room on the ground floor. The total floor area of this room is approximately 1,896 sq. ft. There are also a series of well arranged windows, lighted by concealed lamps so as to comply with the present regulations, and occupying a frontage of 119 ft. 6 in. This is essentially a working showroom. It is not given up to exceptional appliances, although typical lighting units of a decorative kind are on view. But the majority of the articles are such as would be used by the ordinary householder and we understand that, quite apart from the demand for factory lighting which has sprung up in the district owing to the large number of firms working overtime on Government jobs, there has been an excellent business done in ordinary interior lighting.

A characteristic of this showroom is its length, the part shown in the view being less than half of the total area. In the foreground will be seen a series of stoves mounted on a stand, on the left is a decorative coloured glass shade suitable for table-lighting, and on the right a silk shade suitable for lighting drawing

rooms. In the background are a number of other lighting units which serve to show up the array of geysers and hot water appliances at the far end. As the photograph suggests, the lighting of the room is quite brilliant and the contrast with the somewhat gloomy war conditions in the street must be appreciated by visitors.



Lumina Bureau Photo.

A corridor at the offices of the Tottenham and District Light, Heat and Power Co., High Road, Tottenham, lighted by semi-indirect gas units.

Our second illustration was taken on the first floor. It shows an attractive example of semi-indirect lighting by gas, a method which is particularly suitable for corridor illumination, especially when there is an arched ceiling to "set off" the lights. The effect is soft and pleasant, and the brighter bracket lights at the far end of the corridor serve as a kind of

"climax" to which the eye is involuntarily attracted.

On another occasion we hope to refer to the window-lighting and to show how

the illumination has been contrived to comply with the present lighting regulations, and yet to show off the contents of the window to advantage.



Lumina Bureau Photo.

A portion of the Showroom of the Tottenham and District Light, Heat and Power Co., High Road, Tottenham.

(Photo. taken entirely by artificial light.)

THE KEITH SYSTEM OF HIGH PRESSURE GAS LIGHTING.

Elsewhere in this issue appears an account of a paper by Mr. Broadberry giving an account of some high pressure installations at Tottenham and elsewhere, where Keith lamps have been used for factory lighting. At the present moment, when so many firms are working overtime on munitions of war, good industrial lighting illumination is appreciated. In a leaflet recently issued by the Tottenham and District Light, Heat and Power Company, it is remarked:—

"During the months of August and September we are inundated with lighting

orders. If these orders were given three months earlier the mutual benefit is obvious. New factories spring up every day and require to be lighted at whatever season they are built. Some work night as well as day."

High pressure gas is recommended to "increase your output, improve its quality, safeguard the health of your workpeople and reduce your lighting bills."

A number of firms which are using high pressure gas lighting are mentioned, and a series of photographs, taken entirely by artificial light, are reproduced in order to illustrate the results obtained.



"Wirum" Lamps—An attractive Poster Stamp issued by the Brimsdown Lamp Works, Ltd.

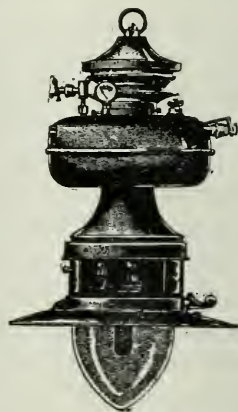
THE PETROMAX LAMP.

The development of emergency work in many districts owing to the sudden demands of the war has stimulated an interest in self-contained portable systems of lighting. The "Petromax" lamp, made by the British Graetzin Light, Ltd., is another example of the use of petroleum with incandescent mantles. Lamps giving 150 to 1,000 candlepower and arranged to give light for 16—18 hours before requiring to be refilled, are now available. Like other lamps of the kind the Petromax lamp is started with a little spirit, but this only takes a few minutes. Special features are the simplicity of design and the "storm-proof" qualities of the lamp, which is claimed to be very serviceable for work in the open.

For emergency work and road-making operations for camps, goods yards, &c., portable self-contained lamps of this kind seem to have considerable advantages and it is not surprising to hear that makers of such apparatus are busy at the present time.



This is the cover of a leaflet recently issued by the Edison and Swan United Electric Light Co., summarising the cost, advantages, and special applications of Ediswan Fans.



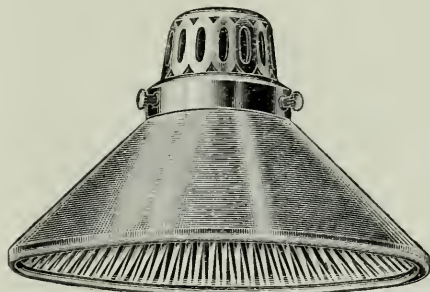
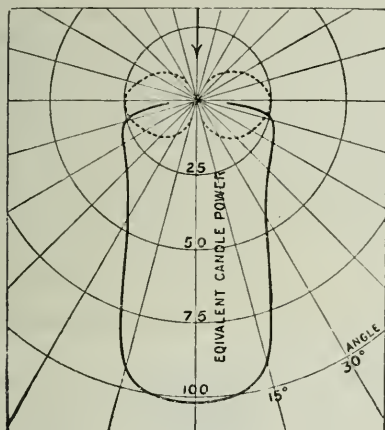
The "Petromax" Lamp.

A NEW REFLECTOR FOR INDUSTRIAL LIGHTING.

The design of good reflectors for factory lighting has much attention recently. Such a reflector is severely tested in practical use. Besides having satisfactory qualities as a distributor of light, it should be capable of being readily cleaned and should collect as little dust as possible; and if possible,

The advantages claimed for the reflector may be summarised as follows:—

1. The scientific light reflecting property of prismatic glassware is increased by the metal reflector.
2. It is easy to clean, both the inside and outside surfaces being smooth.
3. The reflecting surface does not tarnish after contact with the air.
4. The glassware, being protected by a metal cover, is secured from breakage.



Cat. No. 819.

Characteristic Light Distribution Curve.

--- Lamp alone. — Lamp with No. 819.

This reflector gives four times the rated candle-power under the lamp.

the deposit of a certain amount of dust should not materially impair its efficiency.

In the new Holophane Industrial Reflector, illustrated herewith, the ingenious plan has been adopted of spinning an aluminium cover over the prismatic glass reflector, the metal cover merely resting on the apices of the prisms. As a result the natural high efficiency of the prismatic reflector is maintained, and the metal cover completely screens the upper surfaces of the prisms from dust. The inner surface of the reflector, being smooth polished glass, is also free from any tendency to accumulate dirt, and is easily cleaned.

HALF-WATT MAZDA LAMPS.

From the **British Thomson-Houston Co.** we have received a prize list of Mazda Half-Watt lamps, the cover being attractively got up with a view of the special standards for Half-Watt lamps used in Leeds City Square. The lamps are carried by statues, and the effect is distinctly better than that of the ordinary street column.

Messrs. Siemens Bros. Dynamo Works, Ltd., inform us that they have received an acceptance of their tender for the supply of carbon filament lamps to the Belfast Corporation during the ensuing 12 months.

CORRESPONDENCE.

WANTED—A NAME.

April 15th, 1915.

DEAR SIR,

I have been reading the very interesting discussion on Mr. Thorpe's paper. The remarks of Mr. Trotter on the use of the word "fixture" have once more reminded me that I have always had a strong objection to this term, but the persistent use of it by our American friends has almost made me accustomed to it. It is not much worse than the English word "fitting," but neither of these adequately describe a device for not only containing, but improving, the effectiveness of electric lamps, as a modern illuminating device should do.

The word "lantern" is descriptive, and more or less correct for the device

used in street lighting and for commercial purposes, in which a globe contains the lighting units. It is after all a relic of the old lantern in which an open flame was used, and for which protection from the wind was essential.

I know of no suitable name, and think that a new one is justified. The French are a little better off, but they do not appear to have a word which is applicable to all types. "Garniture" (literally furniture, trimming, ornaments) is no better than ours; "lustre" is more suggestive, but of glare; "verrine" has a pleasant sound but refers to glass bowl fittings only. Can someone coin a word?

Yours, &c.,

H. T. WILKINSON.

LITERATURE ON SEARCHLIGHTS.

Through the courtesy of Prof. A. Blondel we have received copies of several valuable contributions to the literature on the Theory of Projectors and Searchlights, and photometry relating thereto, which are as follows:—

Theorie des Projecteurs Electriques, by A. Blondel (Imprimerie Lefebure-Ducrocq, 82, rue de Tournai, Lille, 1894).

Sur les Principes de la photométrie geometrique (Assoc. Française pour l'Avancement des Sciences, 1896).

Sur les Propriétés Photometriques des Lentilles de Projection (Assoc. Française pour l'Avancement des Sciences, 1899).

FEARED LOSS OF MR. G. MAURICE ON THE "LUSITANIA."

We learn with deep concern that Mr. George Maurice, the Manager of the Fittings, Heating and Cooking Department of the General Electric Co., Ltd., was on the "Lusitania," and it is feared that he has perished with the other victims in this terrible disaster.

Mr. Maurice was a member of the Illuminating Engineering Society, and was well known for his active work on behalf of the firm with which he was associated.

Established
1885.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.

Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES

Of Life Assurance, with Various Options

All Classes of Insurance Business Transacted

CHIEF OFFICES:

General Buildings, Perth, Scotland.

General Buildings, Aldwych, London.

General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, May, 1915.

	PAGE
Correspondence, "Wanted—A Name" ..	H. T. WILKINSON .. 236
Editorial	L. GASTER .. 195
High Pressure Gas, Factory Lighting by ..	A. E. BROADBERRY .. 199
Illuminating Engineering Society—	
(Founded in London, 1909).	
Account of Meeting on April 27th	209
Visibility : its Practical Aspects ..	C. C. PATERSON and B. P. DUDDING .. 211
[Discussion :—A. P. Trotter—Dr. W. Ettles—S. D. Chalmers—Haydn T. Harrison— Dr. F. W. Edridge Green—Dr. W. Watson—J. S. Dow—P. J. Waldram—The Chairman (J. Herbert Parsons)—J. G. Clark—J. Dareh—the Authors (in reply) .. 217]	
Visibility, Queries on	210
Illuminating Engineering, Short Notes on ..	227
Metal Works, Lighting of	194
Rates for Factory Lighting	193
Science in the Daily Press	PROF. R. A. GREGORY .. 203
Topical and Industrial Section :—	
Single Lamp Reflectors for Shop Window Lighting	229
Half-Watt Lamps in Selfridge's	230
Showroom of the Tottenham and District Light, Heat and Power Co. ..	232
Ediswan Fans—Brimsdown Poster Stamp—Petromax Lamps ..	234
Lighting of a Blackboard by Gas	238
Insurance Coupon	237
Trade Journalists and the Board of Trade	207

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL ACCIDENT FIRE AND LIFE ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.
GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.
F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

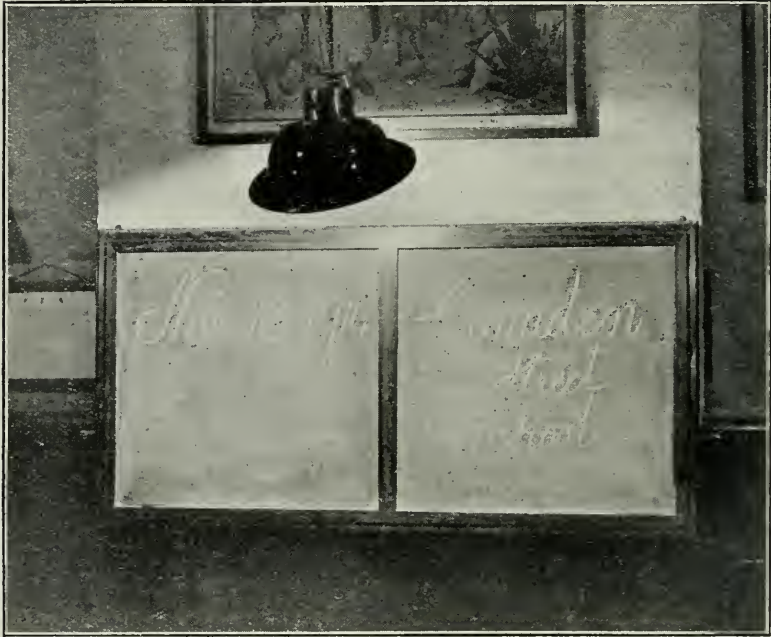
This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

BLACKBOARD LIGHTING IN A MODERN SCHOOLROOM.



We are indebted to the courtesy of the Gas Light and Coke Co. for the above illustration, which shows the special blackboard lighting installed at the Camden Street School (London).

It is now recognised that the illumination on the blackboard should exceed that in the body of the room, so that the eye is naturally attracted to it and is not disturbed by the presence of adjacent brighter objects. It has become an invariable practice at the theatre for the stage to be brilliantly lighted and the auditorium to be darkened; similarly in the schoolroom the blackboard should be the centre of interest. It was suggested,

in the Report on the Artificial Lighting of Schoolrooms issued by the Joint Committee of the Illuminating Engineering Society in 1914, that the intensity of blackboard lighting should exceed that in the rest of the room by 60 per cent.

It need scarcely be added that the source of light illuminating the board should be entirely concealed from the eye, so as to cause no glare.

We understand that the gas fitting shown consumes $3\frac{1}{2}$ —4 cubic feet of gas per hour, and gives an average illumination on the blackboard of 5 foot-candles.



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.

32, VICTORIA STREET, LONDON, S.W.

Tel. No. 5215 Victoria.

EDITORIAL.

The Lighting of Rifle Ranges.

With the Annual Meeting, held on May 18th, the Sixth Session of the Illuminating Engineering Society has come to an end. Readers will find in the Annual Report (see pp. 245-249) a summary of this year's activities, and will readily appreciate the exceptional circumstances by which the Council has been faced in successfully maintaining the work of the Society.

Some important developments of the Society's work have been inevitably postponed, but it was felt to be essential to maintain the continuity of the movement and to select for discussion subjects of special interest at the present moment.

The discussions at previous meetings on such subjects as Searchlights and Visibility brought home to us the close connection between methods of warfare and problems of vision. Before an enemy is attacked his position and strength must be located. Acuteness of vision and instruments for aiding the eye, therefore, play an important role in modern military opera-

tions, and we find that many principles in connection with the use of artificial light in times of peace have also important applications in time of war.

The question of the Lighting of Rifle Ranges, discussed at the Annual Meeting, is an excellent instance of this. At the very outset we are faced by the effect of peculiarities and imperfections of the human eye, and the experience of members like Dr. Ettles who, besides having a special knowledge of this subject, are acting as instructors at rifle ranges, is of great assistance. At the present time many of our members have joined Volunteer Defence Corps and have thus a double interest in the lighting of ranges. The question is by no means so simple as would at first sight appear, and in view of the large number of artificially lighted ranges that are springing up all over the country, the need for some commonly accepted system of illumination is evident. As a preliminary to the discussion we followed the plan, which has proved very useful on previous occasions, of preparing a list of queries to serve as a basis for consideration. These queries were circulated among a considerable number of instructors of musketry and others likely to be interested. Mr. A. P. Trotter, who kindly undertook to open the discussion, as well as other speakers, makes frequent reference to these questions.

Many of them require further study but it seemed desirable to indicate those on which fair agreement has been reached, and we have accordingly prepared a short summary of the views expressed thereon, which will be found on p. 282.

Mr. Trotter has dealt with the subject in a very instructive and interesting manner, describing some of the special difficulties which he has experienced in becoming a marksman. He points out that a considerable section of the people who are interested in shooting in connection with Volunteer Corps, &c., have more or less defective vision, and for them the method of lighting is of particular importance. Although Mr. Trotter tells us in his modesty that almost everyone who took part in the discussion had a larger experience in shooting than his own, we are pleased to record that since the date of the meeting he has passed the tests for the "marksman class" (the highest class) of the City of London National Guard Volunteer Corps. This is surely the reward of perseverance and the result of a scientific attempt to solve some of the problems involved.

Mr. Trotter's opening remarks gave rise to an interesting discussion, and were followed by useful and elaborate contributions by Mr. A. Blok, Mr. J. G. Clark, and others, summarising the results of their tests on various ranges in and around London. We have also been privileged to receive contributions from the Commandants of the Royal School of Musketry at Hythe and of the Royal Marines, Deal, the latter being a succinct reply to the series of questions submitted. We take the opportunity of also thanking the Hon. Secretaries of the various rifle clubs who so kindly granted permission for their ranges to be visited for the purpose of this discussion, and gave facilities for measurements of illumination and photographs of the

ranges to be obtained. As it is hardly possible at the present stage to give a definite reply to many of the points raised, we do not for the moment propose to do more than give the general trend of the discussion. Generally speaking, the methods of lighting on the ranges visited in London, although capable of improvement, are mainly satisfactory in some important respects. In most of the ranges described the illumination on the targets was considered sufficient, and the lamps were adequately screened from the eyes of the marksman. We have, however, heard of other cases in which targets have been insufficiently lighted by unscreened dirty electric lamps or untended flickering gas jets, and it need hardly be said that in these circumstances good shooting is not to be looked for.

An important matter, which requires somewhat fuller inquiry before a definite reply can be given, is the desirable intensity of illumination on the target. The general opinion of those who have tested this point would seem to be that 10—20 foot-candles is ample, that below 5 foot-candles is hardly enough, and that values much above 20 foot-candles are apt, under certain conditions, to give rise to glare. It may come to some people as a surprise to learn that it is possible to overlight a target, but there is good reason to believe that this is so. If the target is too bright it may be difficult to see the bull or the sights distinctly, and there seems to be a certain "glaring" effect.

It goes without saying that the sources of light illuminating the target should always be screened from the eyes of those shooting, otherwise they would dazzle the marksman. But some difference of opinion has been expressed as to the desirability of leaving the firing point in complete darkness. Mr. Trotter and others consider that the violent contrast between the bright target and the adjacent darkness may be trying to the eye and prejudicial to acuteness of vision; also unusual conditions of this kind may give rise to a specialised type of marksmanship hardly applicable to service conditions. In conjunction with Mr. Brazil, Mr. Trotter has devised an ingenious way of avoiding this extreme contrast; in this way one approaches outside conditions more closely, and it is suggested that a certain amount of light from well-screened lamps might be allowed at the firing point.

This would enable the instructor to watch the men firing, and to some people the presence of this illumination would be of assistance in aiming. The question of the type of targets to be employed, and the best background is a somewhat debatable one. If pictorial targets are used the *colour* of the light should receive attention. An old and dirty electric lamp, giving a very yellow light, may make it difficult to distinguish objects (such as a man in khaki, shown in the picture). Possibly for this work lamps of the "artificial daylight" variety would be helpful. The question of the functions of miniature ranges, like the much discussed matter of the use of aperture sights, hardly falls within the scope of this editorial. We think, however, that a good case has been made out for closer investigation of the lighting conditions which are most desirable for shooting on miniature ranges, and the matter might now be taken up by a Joint Committee composed of members of the Illuminating Engineering Society and representatives of Rifle Clubs. It should not be difficult to reach agreement on fundamental points and to draw up a simple lighting specification, which would be a useful guide at the present moment, showing how the desired conditions of illumination may best be realised. Miniature ranges have come to stay, and with a view to the future it is desirable to standardise the essential conditions as far as possible.

Co-operation for the National Welfare.

Since the war began there have been many instances of combination between various interests for the national welfare. We have now a Coalition Government. The technical resources of the nation are being more completely organised, and we may hope that before long national organisation will be placed on a better basis. It is idle to regret lost time, and we are all aware that there is still great room for improvement. There is, however, no need to be discouraged. These defects can and will be made good if only the authorities resolve to utilise to the full the scientific and technical ability available.

An instance of this much needed co-operation was afforded by the recent joint meeting called to discuss the coal situation, at which Sir Corbet Woodall represented the gas industry and Sir John Snell the Institution of Electrical Engineers. To those in the engineering profession it has been recognised for some time that the coal supply was a vital problem. The non-technical public can hardly realise how a shortage of coal affects every branch of industry. In a recent paper before the Royal Society of Arts, Mr. H. M. Thornton gave a graphic account of the many technical applications of gas in the making of munitions, in heating forges and furnaces, drying and heating processes, &c. The writer, from his own experience, can confirm the great utility of gas as a lighting and heating agent.

Equally important are the needs of the electrical industry. The rapid extension of factories now engaged in Government work depends on their equipment with an adequate supply of gas and electricity as well as appliances for lighting and heating.

We are glad to see that the importance of the matter is receiving attention from the Authorities. Following the joint meeting referred to above a conference with Members of Parliament was held at the House of Commons on June 9th, and it is hoped that this will lead to better facilities being given for the supply of coal to the great national industries.

We have also to note the issue of the preliminary report of the Coal-Mining Organising Committee appointed by the Home Office on February 23rd last. The Committee consider the possibility of suspending the Eight Hours Act, and, among other suggestions, the public are reminded of the desirability of economising in the use of light. We of course agree that in times like these people should be particularly careful to avoid waste by burning unnecessary lamps. One of the chief effects of the illuminating engineer is to prevent such waste by the judicious placing of lamps and the use of efficient appliances for distributing the light where it is mainly needed. On the other hand we think it should be recognised that abundant illumination in the factory is not a luxury but an absolute necessity, if good work is to be done and an increased output secured. Those engaged in attending to the lighting of factories are surely doing important and highly necessary work at the present moment.

As a second instance of co-operation we may take the approved scheme for establishing central munitions works in the metropolitan area, so that the workshops and stations of the various companies and authorities interested in the supply of light, power and water, can be utilised for increasing the supply of munitions of war. We are glad to note this new instance of concerted action on the part of gas and electric interests, and we feel sure that during the critical months before us, there will be many other instances of such beneficial co-operation.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ANNUAL GENERAL MEETING.

(Held at the House of the Royal Society of Arts, London, W., at 7.30 p.m., on Tuesday, May 18th, 1915).

THE Annual Meeting of the Society took place as stated above, THE PRESIDENT (Sir William Bennett, K.C.V.O., F.R.C.S.) being in the chair.

The Minutes of the last meeting having been read the Hon. Secretary announced the name of the following new applicant for membership:—

Smith, Chas. Abbots

Fixture Designer, 15, Baring Road,
Addiscombe, Surrey.

The names of applicants announced at the last meeting* were read again and these gentlemen were formally declared members of the Society.

The Hon. Secretary then read in abstract the Report of the Council for the past Session. (See pp. 245—248).

The president said that the Report must be regarded as a very satisfactory one in the circumstances. It contained a record of a great deal of work, carried out in a very energetic manner, and there was good promise for the future.

Mr. F. W. GOODENOUGH (Chairman of Council) proposed the adoption of the report. It was, as the President had

said, a really remarkably satisfactory report considering the very exceptional circumstances that had prevailed during the session. The Society could congratulate itself that it had been able to do some useful work in the present national crisis. The labours of the Home Office Committee on factory light-

ing would also form a monument to the usefulness of the Society, which had taken a prominent part in bringing about the holding of that inquiry and the carrying out of it.

He had pleasure in proposing:—

“That the Report of the Council for Session December, 1914—May, 1915, be formally adopted by the Society.”

Mr. A. P. TROTTER seconded the adoption of the report. It should be a source of great satisfaction to the members to find the useful work of the Society increasing in the way it was. It had been predicted by some people when the Society was first formed,

* *Illum. Eng.*, Lond., May, 1915, p. 209.

that there would not be enough subjects to go round, and that they would be exhausted in two years and then the Society would be wound up. On the contrary, however, not only had they found fresh subjects but on the present occasion, when the whole of our lives and thoughts had been diverted by the war, the Society had been able to have three meetings devoted entirely to war subjects, which, perhaps, would not have occurred to them in more peaceful times. When those times came again he was sure the activities of the Society would be renewed in the directions which had proved so useful hitherto.

The motion was then put to the meeting and declared carried unanimously.

Mr. J. F. CROWLEY then proposed:—

“That this meeting extends a cordial vote of thanks to the President, Council and Officers for their efforts on behalf of the Society during the past twelve months.”

The Society in his opinion, had placed illumination for the first time in this country on a scientific basis, and he wished to mention that, because many of the present officers were responsible for the initiation of the Society. It was also very much indeed to the credit of the officers that they had proved themselves so adaptable in present circumstances. Most of the societies that had had to continue in these strenuous times had found it very difficult to interest their members, but in the case of this Society, the officers had met the strange conditions in a very remarkable way. Papers were read on such subjects as searchlights and the lighting of rifle ranges—subjects of great public interest in the present circumstances. A debt of gratitude was due to the President, Council and officers for the manner in which they had maintained the traditions of the Society.

Mr. M. FOULDS seconded the resolution which was put to the meeting and carried unanimously.

THE PRESIDENT expressed his thanks for the generous way in which the

resolution had been carried. He was sure that all the officers had felt the greatest possible pleasure in doing their work for the Society, and he was only sorry that he himself, owing to circumstances connected with the war and other things, had inevitably been prevented from being present as frequently as he would have liked.

Mr. L. GASTER (Hon. Secretary) also thanked the members on behalf of the officers for the vote of thanks. It was a pleasant task to carry on the work of a Society like this when all the members so cordially supported the Council and officers, and this work would be continued in the future so long as the assistance of the members was given as it had been in the past.

In conclusion the following resolution was moved by THE PRESIDENT and seconded by Mr. F. W. GOODENOUGH. and declared carried unanimously:—

“That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their rooms during the past session, and records its appreciation of the encouragement and support which the Society has received.”

This terminated the formal business before the meeting, and THE PRESIDENT then called upon Mr. A. P. TROTTER to open the discussion on “**Some points in connection with the lighting of Rifle Ranges,**” and a discussion ensued in which the following took part:—Mr. A. BLOK, Mr. SCHAMASCH, Mr. P. J. WALDRAM, Mr. H. BRAZIL, Col. GAITSKELL BURR, Mr. FREAK, Mr. W. J. BASSETT, and Mr. G. HERBERT. The HON. ASSISTANT SECRETARY (Mr. J. S. DOW) also read in abstract contributions to the discussion from THE COMMANDANT of the HYTHE SCHOOL OF MUSKETRY, Mr. FRANK BAILEY, Mr. J. G. CLARK, and Mr. S. G. CORAM.

THE PRESIDENT in closing the proceedings called for a vote of thanks to Mr. TROTTER for opening the discussion and announced that the first meeting of the next Session would take place in November next.

REPORT OF THE COUNCIL FOR THE SESSION.

DECEMBER, 1914—MAY, 1915.

(Presented at the Annual Meeting held at the House of the Royal Society of Arts, on Tuesday, May 18th, at 7.30 p.m.)

THE report of the Council for the period 1914—1915 appears in circumstances very different from those existing at the end of the last session. At that time everything pointed to an active resumption of work in the autumn under most favourable conditions. The international side of the movement had assumed definite shape through the formation of the International Commission on Illumination. The Society in the United States and the newly formed Society in Germany were actively carrying on their work and in France and Belgium the movement was also making steady progress. Active steps were being taken for the extension of the work of the Society throughout the United Kingdom and the official organ of the Society for August contained a special summary, giving the aims and the work so far performed by the Society. It was intended to send out this number with a view to enlarging the membership of the Society and increasing its scope of operations.

Scarcely had this issue appeared when the war was upon us. International co-operation was brought to a standstill, and it became evident that the proposed widespread effort to arouse interest in the movement would have to be postponed.

Nevertheless it was felt to be essential to maintain the continuity of work of the Society as far as possible, and it was hoped that the present exceptional circumstances, while checking the activities of the Society in some directions, would provide opportunities for useful work in others, light being necessary in all times, alike in peace and in war.

MEMBERS ENGAGED IN WAR WORK.

It need hardly be said that the carrying out of the usual programme of the Society

presented difficulties. Many of the younger members have joined the forces; others have been engaged in special professional work for the Government. Our President, for example, has been very fully occupied in medical work in connection with the war. Other members have been necessarily immersed in extra labours caused by the withdrawal of so many men from their ordinary occupations, and the dislocation of business conditions generally. A considerable proportion of the members of the Society have been engaged in the important duty of maintaining the supply of gas and electricity, and the exceptional demands of factories engaged in preparing munitions of war on the one hand, and the unusual requirements as regards diminution in public lighting on the other have added to their responsibilities throughout a difficult period. Members interested in acetylene, incandescent oil and similar portable systems of lighting have been very busily engaged in Government work. Many members also have undertaken new responsibilities as special constables or in connection with volunteer corps.

MEMBERSHIP MAINTAINED.

In the circumstances it was also natural that there should have been a certain number of resignations and a considerable increase in membership during the year could scarcely have been anticipated. We are glad to say, however, that the present number of members stands at a figure slightly above that prevailing at the commencement of the war. All things considered the Society may congratulate itself on this result under such unfavourable conditions.

During the session Sir Corbet Woodall and Mr. Thomas Alva Edison have accepted nomination as Honorary

Members of the Society, and in accordance with the arrangement made with the Institutions of Gas and Electrical Engineers last year the President of these two bodies, Mr. Bond, and Sir John Snell were invited to act upon the Council of the Society.

At the commencement of the session the question arose whether the ordinary programme could be carried out; in view of the many important applications of light illustrated by recent events, it was decided to hold regular monthly meetings, but to select, as far as possible, subjects for discussion which would be of special interest at the present time.

MEETINGS OF THE SOCIETY.

Five meetings, not including the Annual General Meeting, have been held. At the opening meeting on 1st December, 1914, there was a general discussion on Illuminating Engineering in War Time. Some of the problems arising through the war were considered and reference was made to the alterations in outdoor lighting that have been made, as a measure of precaution against hostile aircraft. It was pointed out that the methods of concealed window-lighting recommended at previous meetings of the Society, and the avoidance of glaring sources were best adapted to comply with the requirements made by the authorities.

In this discussion it was considered expedient to avoid any detailed comment on or criticism of the alterations in public lighting made since the commencement of the war, the aim of the Society being simply to assist its members and the public in complying loyally with any steps taken by the authorities in the interests of public safety.

The framing and carrying out of general regulations for the lighting of shop-windows and streets in war time, undertaken at short notice, was doubtless a difficult task. Not unnaturally the regulations were interpreted somewhat differently in the various districts, and it was thought the Illuminating Engineering Society, whose members were accustomed to the consideration of such matters, might be of service. Accordingly, a Committee, including some members of the Society who were also members

of the Anti-Aircraft Corps, was formed with a view to making some definite recommendations on shop-window lighting, which would enable the requirements of the authorities to be most satisfactorily fulfilled. After several meetings suggestions were prepared and submitted to the authorities by whom they were sympathetically received and considered.

In view of the great changes made in public lighting since the war began, the Council thought that a record of these conditions might with advantage be kept, by means of photographs and measurements of the conditions of illumination prevailing in the streets of London. Permission has been granted to the Hon. Secretary for this to be done, on the understanding that none of the data should be published until the conclusion of the war.

It is hoped that when that time arrives some interesting data will be available.

The Council takes this opportunity of expressing its thanks to the authorities for the facilities granted in this connection. It is probable that some useful lessons may be learned from the exceptional lighting conditions now prevailing, which will not be without influence on the methods of illumination to be adopted in the future.

The second meeting of the Society on January 19th, 1915, was again devoted to a subject of considerable topical interest, namely, the Scientific Development and Practical Applications of Searchlights. The discussion was opened by Mr. P. G. Ledger and special contributions were made by Mrs. Hertha Ayrton, Mr. A. P. Trotter, Prof. A. Blondel and others. In this discussion it was considered essential to avoid any reference to the arrangements made for home defence, and there were many matters which it was considered inexpedient to mention at the present moment. Notwithstanding these limitations, however, the discussion proved a most useful one and the record of the meeting as reproduced in the official organ for February, 1915, was considered an important contribution to the knowledge of the subject, many problems of more than ordinary interest being suggested.

In view of the restrictions on public lighting it was thought that a paper

dealing with some aspect of interior illumination would be appreciated. Accordingly, at the following meeting on February 16th, 1915, a paper was read by Mr. F. W. Thorpe on the "Development of Fixture Design in Relation to Architecture, Illumination and Interior Decoration." The subject is one of considerable interest to members of the architectural profession and should be the means of drawing the attention of architects to the work of the Society.

On March 16th there was a discussion on the "Marking and Rating of Lamps and the best Methods of Specifying their Illuminating Value." A special contribution was presented by Mr. F. W. Willcox and the discussion was opened by Mr. C. A. Wordingham. The subject is a very important one, both to lamp manufacturers and to the general public, and it is hoped that the discussion will pave the way for the solution of what is admittedly a very complicated question. The experience of the past few years has shown the desirability of some more definite and generally accepted method of marking and rating lamps, and it was thought that an open discussion on the impartial platform of the Illuminating Engineering Society, which includes among its members manufacturers of lamps, both gas and electric, as well as engineers engaged in making use of them, would be helpful in paving the way for such an understanding.

The succeeding meeting on April 28th was given up to a discussion on "Visibility—its practical aspects" which was opened by Mr. C. C. Paterson and Mr B. P. Dudding. This discussion was in several respects supplementary to that on Searchlights, and dealt with many points of considerable interest at the present moment.

The subject of discussion at the final meeting of the session on May 18th, "The Lighting of Rifle Ranges," is again one of topical interest. A very large number of these ranges are being constructed at the present time and in view of the important effect of the conditions of illumination on the convenience of marksmen, a specification of the lighting conditions would be a useful guide to those engaged in their construction.

It will be seen that the Council have

been able to continue meetings as usual during the Session in spite of the difficulties imposed by the war, and by the selection of suitable subjects interest has been kept alive. The attendance at meetings has been more than maintained and the standard in the discussions has been uniformly high. The subjects have also been such as to interest new circles in the work of the Society and connections have been established which should be helpful in time to come. The interest aroused in the papers during the present session has shown the necessity for the platform offered by our Society for the discussion of the many lighting problems awaiting solution.

INTERNATIONAL CONGRESSES, COMMITTEES, &C.

In conformity with the practice of most other societies the Annual Dinner was not held this year on account of the war. There is, unfortunately, little to report regarding proceedings of international congresses. The Illuminating Engineering Society in the United States, however, has continued its work as usual, and a number of valuable papers were read at its Eighth Annual Convention at Cleveland. The National Illumination Commission in this country has held several meetings, and proposes to carry on its work, although during the war various matters which would otherwise have been actively taken up have necessarily been postponed.

At the present time, when so many factories are working overtime on Government work, the subject of industrial lighting is being given special prominence, and the Report of the Departmental Committee appointed in 1913 by the Home Secretary to inquire into the matter is being awaited with considerable interest. We understand that the work of the Committee has proceeded steadily since the war commenced, and its Report, when issued, should do much to encourage more scientific methods of illumination.

ADDITIONAL SUPPORT REQUIRED.

The position may be summarised by saying that in spite of the unprecedented conditions arising through the war, the Society has been able to maintain its

useful work. The Society has again benefited by the arrangement providing for THE ILLUMINATING ENGINEER to act as the official organ and to undertake the publication of transactions, the cost of which would otherwise be prohibitive. It has been fortunate in not being called upon to pay many customary expenses, such as rent of offices, secretary's salary, &c.

A debt of gratitude is also due to the Hon. Officers of the Society whose labours have been considerably increased owing to the exceptional circumstances of the past session.

It is becoming evident that in order to make any substantial progress the Society must either secure a considerably enlarged membership or consider an increase in its present moderate subscription. The Illuminating Engineering Society in the United States, in spite of its vastly greater membership, has experienced similar difficulties and is now considering a scheme for dividing members into two classes, namely "members" and "associate members," paying respectively subscriptions of two guineas and one guinea per annum.

The Council consider that additional funds are needed to enable the work of the Society to be carried on in a satis-

factory manner, and desire to emphasise the importance of securing additional members. It is laid down in Article 23 in the constitution of the Society that "any member may commute or compound for all future payments and become a member for life, by payment of a sum of not less than £10 10s. (ten guineas)." It is hoped that a number of members will take advantage of this method in order to provide additional funds.

PROGRAMME FOR THE NEXT SESSION.

The Council is now engaged in considering the programme for the next session. Members who are willing to read papers are invited to notify the Hon. Secretary as soon as possible, and to send in contributions early in the vacation.

The Council takes this opportunity of inviting any further suggestions as to the future work of the Society, or any subjects which might receive special attention during the next session.

WILLIAM H. BENNETT,
President.

F. W. GOODENOUGH,
Chairman of Council.

LEON GASTER,
Hon. Secretary.

APPENDIX.

LIST OF SUGGESTED SUBJECTS ON WHICH PAPERS ARE INVITED.

THIS list is intended to be suggestive, but is not exhaustive, and the choice of subjects for the next session will naturally be conditional on future events.

It need scarcely be said that all papers and discussions will, as hitherto, be conducted in accordance with the restrictions imposed by the authorities for the safety of the country.

1. Special applications of light in connection with the war.
2. Problems in the lighting of camps, barracks, field hospitals, &c.
3. The use of portable illuminants in emergency work in factories, goods yards, and dockyards, for roadmaking, &c.
4. Specific problems in the lighting of factories and workshops. Results accomplished by the use of illumination by high pressure gas, gas-filled electric lamps, &c.
5. Illumination and portable safety lamps for mines, &c.
6. Modern methods of lighting and illuminants employed in ships, lighthouses, buoys, coast-lights, beacons, &c.

7. The measurement of daylight and its application by the architect to designing window-space, and the access of natural light to interiors. The value of photometry in deciding ancient light cases.
8. Simple methods of calculating beforehand the distribution and intensity of illumination in interiors.
9. Instruction in illuminating engineering: Courses of lectures and laboratory work, &c.
10. The benefits of good illumination from the insurance standpoint, and as a means of preventing accidents.
11. New forms of instruments for measuring light and illumination and new apparatus for use in the photometrical laboratory. Methods of testing colour. Methods of testing the steadiness of sources of light.
12. Special problems in fixture design: the compromise between artistic and illuminating principles.
13. Decorative lighting and illuminating engineering from the standpoint of artistic effect and architectural principles. Possible application to the lighting of streets, squares, &c.
14. The production of light of various colours, and the best means of modifying the spectra of artificial illuminants so as to resemble that of daylight.
15. Problems encountered in the lighting of museums, picture galleries, &c.
16. The decorative lighting of parks, avenues, and flower gardens, fêtes, &c.
17. The physiological aspects of illumination, and the effects of artificial light on the eyes.
18. The correct application of light in projection, searchlights, lanterns, cinematographs, &c.
19. The lighting of billiard tables and other indoor games.
20. The artificial illumination of athletic grounds, tennis courts, skating rink, bowling alleys, &c.
21. Country house lighting by private electrical installations, by acetylene, or by petrol air-gas and incandescent oil vapour.
22. Theatre lighting: Illumination on the stage and its use to produce scenic effects, &c.

POPULAR LECTURES ON ILLUMINATION IN THE UNITED STATES.

At a meeting of the Council of the Illuminating Engineering Society in the United States on May 13th, Prof. C. E. Clewell reported for the Committee on Popular Lectures. He stated that the manuscripts of the first two lectures had been received. These lectures would deal with Residence Lighting and Store Lighting respectively and would be

submitted to the Council for approval very shortly. The Committee has in preparation a series of five lectures dealing with industrial, store, office and residence lighting, and one on the fundamentals of light and illumination. It is intended that copies of these lectures, which will be presented in an attractive and elementary form, will be available for loan to those who wish to give addresses on the subjects, and lantern slides will be prepared to illustrate them.

SOME QUERIES IN CONNECTION WITH THE LIGHTING OF RIFLE RANGES.

THE following series of queries was prepared as an introduction to the discussion on the above subject, and has been circulated among a number of experts and authorities on musketry.

This list of queries is not intended to be exhaustive, but merely to serve as an indication of the scope of the discussion. It will be observed that a number of those who took part in the discussion refer to special aspects of the question which have come within their experience.

The following are some of the suggested points dealt with in the discussion :—

(1) Should the main object of a miniature rifle range be to afford an opportunity for learners to practise the art of holding a rifle, aiming or firing under simplified conditions, without regard to the reproduction of ordinary practical conditions ?

(2) Assuming that artificial lighting is employed, should this be used mainly or solely to illuminate the target with the object (rightly or wrongly) of simplifying the conditions and making them easier ?

(3) Do these artificial conditions of lighting conduce to skill in a specialised and artificial type of shooting ?

(4) Assuming that the light is concentrated solely on the target and that conditions for highest acuity of vision of the target are desired, what is the best degree of illumination ? Does an excessive illumination lead to "irradiation" (*i.e.*, an apparent encroachment of the white surface over the black bull) ; if so, what should be the permissible limit of illumination to avoid this effect ?

(5) Does a dark background for the target (*a*) conduce to acuity of vision ? (*b*) assist in aiming—or does it introduce difficulties ?

(6) Does concentration of light on the target and darkness in other parts of the range, resulting in the enlargement of the pupil of the eye, have an effect on acuity of vision (*a*) of the target ? (*b*) of the sights ?

(7) Is it desirable for miniature ranges to use targets in which the contrast between the bull's-eye and the card is less than that obtained by printing black on white ?

(8) Is it agreed that sources of light used to illuminate the target should be completely screened from view ? Is it better to have the surroundings comparatively dark or to have a more moderate contrast between surroundings at target ? Is there any general understanding as to whether results by artificial light are better or worse than those obtained in daylight ?

(9) Is it desirable to attempt to produce conditions of light similar to those existing out of doors ? If so, what steps should be taken to imitate these conditions ?

(10) What special lighting arrangements, if any, are desirable to facilitate the observation and recording of results and the manipulation of targets from the firing end ?

SOME POINTS IN CONNECTION WITH THE LIGHTING OF RIFLE RANGES.

BY A. P. TROTTER.

Introduction to Discussion which took place at the Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8.15 p.m., on Tuesday, May 18th, 1915.

In opening the discussion on the lighting of rifle ranges, a word of personal explanation is needed. I have some acquaintance with the science and technology of illumination, and with the elementary physiology of the eye, but I have accepted the invitation to start the proceedings to-night, not because I am an experienced rifle shot, but on the contrary, because I have encountered such difficulties that I can perhaps present them for consideration more vividly than one who is a good marksman, and who only hears of these difficulties from his pupils. I hope by submitting these to experts to obtain help for others.

Before turning to the question of the lighting of rifle ranges, let us consider what rifle shooting consists of. It may be divided into three kinds. The use of service rifle and ammunition on ordinary open air ranges, the use of the Morris tube or miniature rifles on open air ranges, and lastly of miniature rifle ranges illuminated by artificial light, and from which day light is generally excluded.

Dismissing "grouping" practice and rapid firing, the object is to place as many shots as possible as near the middle of the bull's eye as possible. We may dismiss too the various positions of the marksman's body and of his arms, the art of trigger pressing, and deal exclusively with aiming and the considerations of lighting which affect this.

The recruit is shown the foresight and the notched backsight of a rifle, and is

told to hold it or to place it on a stand so that the top of the backsight is level,



FIG. 1.

the top of the foresight is exactly in the middle of and in a line with the top of the backsight, and the bull's eye touching or as it were resting on the tip of the foresight. This instruction is elucidated by diagrams showing the right way and several wrong ways of aiming.

Now this is a bad beginning, for the recruit tries, and at once finds that it is impossible to see anything of the kind. If he has normal sight he can see the bull's eye clearly. The foresight is about 39 inches from his eye, and if he directs his attention to it he can see it clearly. The backsight with the notch is about $17\frac{1}{2}$ inches from his eye. If he looks at it with both eyes he may see it clearly, with one eye not so well, but to see all three clearly at the same time is impossible. What is possible is to



FIG. 2.—Appearance of sights against a white target 6 inches wide on a dark background.

put the rifle in such a position that when attention is directed, or in other words

when the eye is focussed on each of the three objects in succession, they appear to be in alignment. Finally, attention is always directed to, and the eye is focussed on to the target. If the learner is long sighted, short sighted or astigmatic and cannot see the target clearly, he can use glasses which will remove that disability and he will start fair with normal sighted men.

A middle aged or elderly man has greater difficulties in sighting, and these become much more serious in a weak light. A year ago not much attention would have been paid to this. Musketry instructors had to deal with young men, and rifle shooting for middle-aged men was only an amusement. To-day there are thousands of volunteers of ages between 40 and 70 or older who having struggled for permission to bear arms, wish to know how to use them, when they get them.

The crystalline lens of the eye is a stiff jelly surrounded by a muscle called the ciliary muscle. When this muscle contracts the lens becomes bulged and increases in optical power. In youth this accommodation as it is called is considerable, but with advancing age it diminishes, because the lens becomes more rigid. Sometimes the lens puckers when it bulges, possibly because it is stiffer in some directions than in others, for its structure is not homogeneous. This causes temporary astigmatism, but it may be removed completely by the use of ordinary reading glasses which make no call upon the focussing property of the eye. Judging from the experience of my friends, my own eyes are fairly representative of this class. My vision is normal, and so far as I am aware, perfectly free from astigmatism for distant objects. I can see shot holes about $\frac{1}{2}$ -inch diameter on a target by daylight without a glass, at 25 yards, subtending an angle of about 27 seconds. I did not begin to use glasses for reading until I was 54, that is, four years ago. Many years ago, on the very few occasions that I used a rifle, I found that I was a tolerable shot, probably owing to "duffer's luck," a well recognised condition which does not seem to have been explained by physiologists or psychologists. In February last I went to a gas-

lighted miniature rifle range, and was disgusted to find that while the target was clear, the backsight was a mere blur or cloud and that while the rifle was tilted upwards I could see the foresight, but when I brought it down into the fuzzy foresight I saw multiple and uncertain images. Holding the rifle steady, and moving my eye from side to side horizontally, these images moved in a capricious way. I spent some time in practice shooting, trying to find some definitely reproducible arrangement of the images of the foresight. The only thing to do in such circumstances is to discover something definitely reproducible and stick to it. I have found no account of the phenomenon in any official handbook on musketry, no instructor has given me any help. A writer on "How to become a marksman" finishes a short article as follows: "Men over 40 years of age are lucky if they can see the backsight clearly as well as the bull's eye. The usual feeling is that there are two or three overlapping each other, producing a smudgy appearance. I suggest the use of glasses which will clear the bull's eye, and you must deal with the backsight as the batsman did who could see several balls at once—go for the middle one." Now this gives no help. In the first place I find and others find that the foresight and not the backsight has a multiple appearance, the backsight it is true looks smudgy. But glasses to clear the bull's eye are not needed, and any one who can see the target clearly without glasses will assuredly see it less clearly with glasses.

I found at last, that by taking a very fine sight, that is, allowing only the extreme tip of the foresight to appear, the third image was suppressed but the foresight was double. This position would shoot low, and it was necessary to aim high or to raise the sight. The direction was definite, but the elevation was difficult. The smallest motion of the head sideways caused complicated images to appear. An experiment made by Mr. S. D. Chalmers showed that this was not due to a defect in my eye, but it can be reproduced by projecting on a screen the images of a slightly out of focussed pin and a much out of focussed notch. The scientific consideration of

these would be beyond the scope of the present discussion unless someone will tell us how they may be definitely utilised in aiming.

It seemed hard to persevere with these experiments when a simple device has been provided which does away at once with all the trouble. This is the aperture or orthoptic sight, nothing more than a small diaphragm or peep hole fastened to the rifle. But the use of such a sight is forbidden in the passing tests of the Corps to which I have the honour to belong. "Ours not to reason why," but one may guess that the aperture sight as usually constructed is more liable to damage than the ordinary open sight. We need not grumble, the test is an easy one, and would perhaps be too easy with an orthoptic sight. Several men who were shooting no better than I, seemed to experience the same troubles, and some despaired of passing the first test.

A few weeks ago I had the opportunity of shooting with service ammunition on an open air range at 200 yards. On taking aim I was surprised to see a single foresight and a tolerably distinct backsight. It stood out against the butts far more distinctly than in a dark range. I threw over my carefully devised plans for aiming, and applied the ordinary official rule with satisfactory results.

I had tried without success to investigate the multiple images by experimenting with improvised sights in an ordinary room, but I could not reproduce them. After a few minutes experience with a rifle in broad daylight it occurred to me that the difficulties arose in the dark and that the pupil of my eye would then be enlarged. On repeating my experiments in a dark room I found it easy to reproduce these phenomena. Mr. Chalmers points out that in a darkened range the diameter of the pupil of the eye is considerably greater than the width of the notch of the backsight.

My next step was to search for an open air miniature rifle range, and having discovered one, I was not surprised to find that aiming according to the usual rule was applicable. I used the two inch bull's eye, because I have to pass my test on it. I prefer the one inch. On my third attempt, 8 shots out of 10

were on the black, the two others being on the next ring (counting 8). This was encouraging.

But the test by gas light had to be passed,* and practice by day light was only for personal gratification and for anticipation of the real thing. I tried the weakest pair of spectacles that I had, of a power of $\frac{1}{2}$ dioptre. This made the foresight clear, but the bull's eye was quite out of focus. It was possible to aim at the middle of the smudge, but the results were not good enough. After some trouble I obtained a pair of $\frac{1}{4}$ dioptre. In order to raise the lens to the proper position I wear them upside down. The bull's eye is tolerably clear but the foresight becomes misty when it is lowered into the V of the backsight, and the two little duplicate images begin to appear. The result is perhaps a good compromise.

The difficulties which I have described at perhaps too great length arise from two physiological causes: the diminished accommodation owing to advancing age, and diminished definition owing to the enlarged pupil, this being due to the feeble illumination of the miniature range. Excellent shooting is being done every day in these ranges by young men and women and no doubt also by middle aged men who are naturally good shots or experienced in that kind of shooting. It is an amusing pastime, almost as good for a steady hand and eye as billiards, but it affords practice only in some of the requirements of practical rifle shooting.

Passing now to the questions which have been prepared for our consideration, I think that we may agree that even a dark miniature rifle range affords an opportunity for learners to practise the art of holding a rifle, aiming, and trigger pressing, and these are undoubtedly the first elements of rifle shooting. If they acquire competence here, they will doubtless do well with service ammunition in the open. But the point which I wish to urge is that

* Since this was written, an opportunity has been given for passing the tests on an outdoor range. Many members of my Corps, including myself, who had shot badly in an artificially-lighted range of the usual type, had no difficulty in passing the test.

if they do not succeed in the dark, they should not be discouraged but should try a daylight range.

The second question assumes that artificial light is used, and asks whether it should be used mainly or solely to illuminate the target. Opinions probably differ here, for nothing but a definite demand could have led to the careful exclusion of light from most of the miniature ranges. The probable reason for this is that other lights than the carefully concealed ones which light the targets would cause glare unless very evenly diffused. It must be admitted that these conditions conduce to skill in a specialised and artificial kind of shooting.

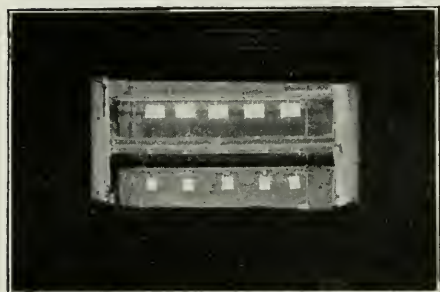


FIG. 3.—Typical indoor Miniature Range.

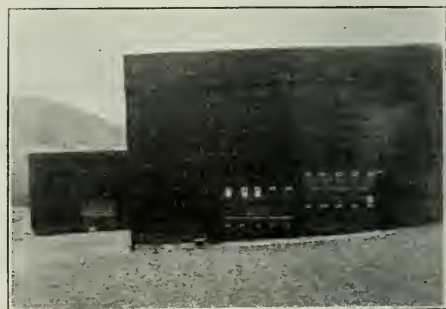


FIG. 4.—An outdoor Miniature Rifle Range.

Showing characteristic difference in the conditions of contrast in the ordinary indoor range (firing point in complete darkness) and in the case of a similar range out of doors.

I will leave the fourth question to Mr. Dow or to others who have made measurements of the illumination in several ranges. A target may certainly be too brightly illuminated, but the disturbing effect seems to be due to glare rather than to the apparent reduction of the diameter of the bull's eye by irradiation.

There seems to be a demand for dark backgrounds, and I can only express my own view on this, but I know that it is held by others. I find that the targets used in the miniature ranges are so small that they do not afford a background for the top or shoulder of the back-sight. In the open air, even a black

board illuminated by day light is so grey that the back sight can be seen against it. In one open air range, targets are sometimes fastened against clean white boards. This is a great advantage for elevation.

of an enlarged pupil they have the power of accommodation or focussing: but older men have much more difficulty with the sights in a dark range than in a light one. I can offer no opinion on the question of using other contrast than white and black for the targets. The target is admittedly a conventional object. We have others in our thoughts.

The reply to the first part of the eighth question undoubtedly is that sources of light should be screened from view. A light over the heads of the marksmen probably leads to low shooting. The last part of the question as to whether the results by artificial light are better

or worse than those obtained in daylight should be answered by those who have much wider experience than mine. The Official Military Book on Musketry Regulations, Part II., states (p. 46) "Indoor ranges, if suitable lighting arrangements are made, can be used for firing at night almost as satisfactorily as by day." "As much light as possible, preferably from above, should be admitted at the target end."

out of doors so far as diffusion of light is concerned, and it should be quite practicable.

Mr. H. Brazil has kindly carried out a suggestion of mine at a private range belonging to the electric lighting company of which he is engineer. Fig. 5 shows a side view and Fig. 6 a view taken from the firing point. The targets are placed against a white paper background 5 ft. high and 8 ft. wide. Two screens of white paper

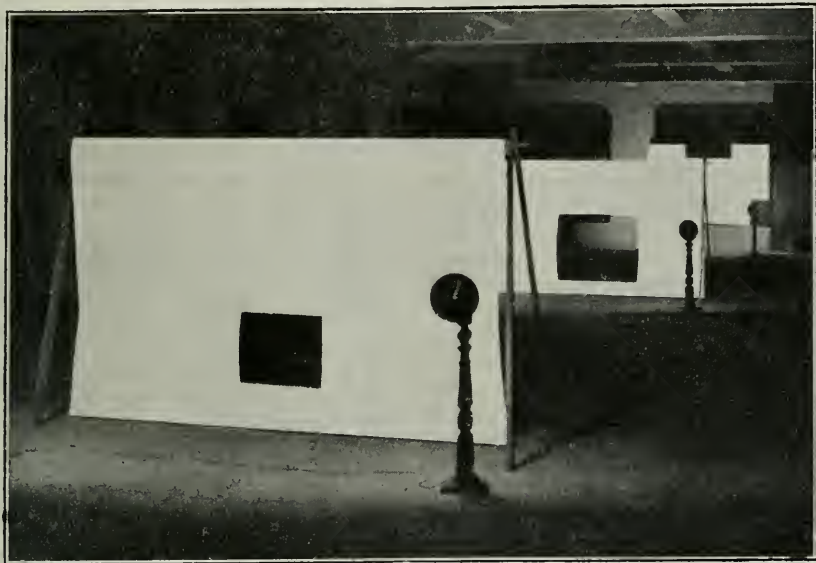


Fig. 5.—Special arrangement of a series of illuminated white screens having apertures through which the target is viewed.

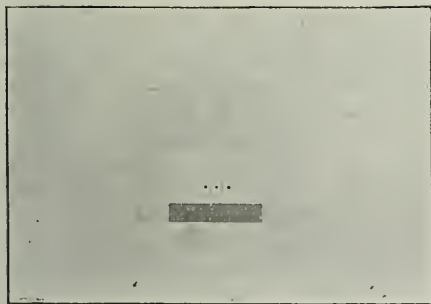


Fig. 6.—View looking through the aperture at target as shown in Fig. 5.

My reply to the ninth question is that it seems desirable to attempt to produce conditions of light similar to those existing

also 5 ft. by 8 ft. are arranged, one at 10 ft. the other at 40 ft. from the firing point and apertures are cut in them. The aperture in the middle screen allows nearly the whole of the background to be seen, and the aperture in the front screen allows nearly the whole of the middle screen to be seen. The screens should have an illumination of not less than 5 foot-candles, and the targets and background might be more strongly illuminated. The object is two-fold, to give a background against which the shoulder or flat edge of the backsight can be seen, and to give a large flux of light which will cause the pupil of the eye to contract. Where several men shoot together the apertures would be wide.

Continued Discussion on Lighting of Rifle Ranges.

Mr. A. BLOK said he would confine himself chiefly to the illuminating engineering side of the problem and leave others to deal with the military and physiological aspects. He agreed most emphatically that the object of lighting miniature ranges should be to make the conditions as easy as possible for the users. The work carried out on such ranges was by no means final, but it was an important preliminary to work on outdoor ranges and under service conditions. He was also of the opinion that in lighting ranges artificially the effect to be sought should be to direct light on to the target and not pay too much attention to the surroundings. Referring to the question as to whether the targets should have a bright or a black surround, his opinion, formed after the examination of several ranges, was that the most comfortable conditions were obtained when the targets were mounted on a background of intermediate brightness. He, personally, had experienced the greatest visual comfort on a range having a brown card mounting for the targets, the target brightness being about double that of the surround. Thus, with a surface brightness of 10 foot-candles on the target, good results were obtained if the surround had a brightness of about 5 foot-candles. He thought that the usual white target with black bullseye was most suitable for beginners because, although there seemed no doubt that a man's shooting at a certain stage of proficiency could be very much improved by the use of targets having a contrast less than that of black and white, these targets of low contrast gave the beginner poor scores and therefore discouraged him. It must not be forgotten that the psychological side of marksmanship is an important factor.

He inclined to the belief that the question of whether the light used to illuminate the target should be completely screened from view or not had not yet been properly investigated. It might generally be taken as bad to have exposed lights on the range, but a great deal might be effected by providing a well-diffused and moderate general illumination around the firing-point. He thought that the practice of keeping the firing-point in

darkness was bad, for the reason that it was dangerous and uncomfortable. Furthermore, it made the instructors' work more difficult and probably conduced to optical fatigue by compelling the marksman to look from the brightly-lighted target to the gloom of his immediate surroundings when loading or giving attention to any other matters on the firing-point.

He would be very glad if Mr. Trotter would say whether he thought that a material improvement was effected by the use of the white screens in the case of the Charing Cross range. Mr. Trotter had said that the result was good, but it would be interesting to know if there was a considerable improvement.

With regard to the desirability of having special lighting arrangements to facilitate the observation and recording of results, that was often a very difficult matter to achieve. Generally, by reason of practical considerations, it was not possible to provide special illumination for "spotting" or counting the scores, and the ordinary condition seemed to be that the illumination on a range must do for all purposes without the option of changing it for special purposes. The matter seemed important, however, because in the opinion of some range officers spotting work was far more fatiguing to the eye than the actual aiming itself during a prolonged spell of work. There was, in this connection, the possibility of an interesting application of the Galilean telescope, and he believed that experimental work upon this matter was being carried out by Mr. F. Cheshire. With an ordinary telescope, there were ten air-glass surfaces giving a total loss by reflection, on an average, of 33 per cent. of the light coming from the target to the eye, but with the Galilean telescope there were only four air-glass surfaces, giving a total loss of 15 per cent. Therefore, it seemed that it would be worth while to develop a simple form of Galilean telescope for spotting purposes. The drawback with the Galilean telescope was that it had a very small field and, accordingly, it would only cover one target or a portion of one target in place of the large surface

which could be covered with an ordinary terrestrial telescope.

As to the degree of illumination necessary upon a target, he had carried out experiments in conjunction with Mr. A. Schamasch on S.M.R.C. bull targets and Bisley 200 yards and 500 yards figure targets.* Arrangements were made whereby the target illumination was raised from 0.8 foot-candles to about 500 foot-candles, the high illuminations being obtained by means of a 2,000 c.p. gas-filled lamp kindly lent by Mr. F. W. Wilcox. With the bull target and an open sight, the most comfortable illumination was found to be about 12 foot-candles. Beyond that, a reddish colour fringe began to assert itself along the back sight and at 50 foot-candles this fringe had so far increased as to make the shooting very difficult. Multiple images or "fuzziness" also appeared, giving a dark halo around the fore and back sights, and when the illumination had increased to values between 60 and 100 foot-candles the bull became visible *through* the fore sight, which was a rather unexpected result. At 200 foot-candles, the glare from the white card became very bad—the target was, in effect, a powerful secondary source of light—and aiming became very difficult.

When an aperture sight was used on the bull target a similar sequence of events was found, but the illumination for most comfortable aiming was slightly higher than with the open sight, as would have been expected. There seemed little doubt that the aperture sight gave a more comfortable result provided that the illumination was sufficiently high to enable the target to be seen through the opening. It was found that beyond about 50 foot-candles troubles due to diffraction effects or irradiation (it was sometimes difficult to separate the two)

increased when the aperture was made smaller.

With the figure targets, substantially the same troubles were found as with the bull pattern, but the most comfortable aiming was done at about 15 foot-candles with open sights and from 20 to 30 foot-candles with aperture sights. Here, again, it was found that from 100 foot-candles upwards it was impossible to aim comfortably with open sights, notwithstanding that this illumination is far less than that obtained on daylight ranges. These experiments seemed to lead to the following conclusions:—(i.) It is possible to over-light a range; (ii.) For a black and white bull target, 12 to 15 foot-candles is a comfortable illumination, whilst for figure targets of the nature used, the illumination may be from 20 to 30 foot-candles; and (iii.) The aperture sight gives easier aiming than the open sight on a range lighted artificially similar to the one used for these tests. It must be borne in mind, of course, that the above figures apply to the eye of one observer, and although the eyesight of the observer might be accurately described as normal it was possible that other observers would find that their requirements were different.

SOME EXAMPLES OF THE LIGHTING OF MINIATURE RIFLE RANGES.

Mr. Blok then showed a number of lantern slides of ranges on which he had experimented, together with the curves showing their distribution of illumination. The data for these and some other ranges are here appended, and in connection with them it may be explained that the ranges were tested exactly as they stood, without any special cleaning or adjustment of the lighting equipment. In some cases, shooting was actually interrupted for the purpose of making the photometric tests as the object throughout was to obtain values representative of practical conditions.

Ranges of the National Reserve City of London Battn: Rifle Club, Blackfriars.

The National Reserve Rifle Club has two ranges extending under the Thames Embankment, and each containing two

* The S.M.R.C. target has a black bull on a nominally white card, and the figure targets have a brown mark, representing conventionally the front elevation of a prone man. The mark lies partly on a green field and partly against a grey sky, the junction of the field and sky being a horizontal line across the target. The targets used in the tests had surface brightnesses in the following ratios: brown: green: grey for the 200-yards target were as 1:1.8:3.7 and for the 500-yards target as 1:2.2:3.4.

superposed rows of targets separated from each other by a horizontal partition, as shown in Fig. 1. On both ranges the targets are lighted by a row of electric lamps near the ceiling and another just below the floor level, and the partition

matic glass reflectors. At the time when the tests were made, these reflectors were all very dirty and portions of some had been broken away, no doubt by ricochet bullets. The middle lamp of the lower row was entirely without a reflector.

The walls of the range tunnel and the background beyond the targets are dark, but whitewash has been put on the underside of the horizontal partition and on the walls along a strip extending about ten feet from the targets towards the firing-point.

Fig. 1 shows the arrangements in the right-hand range, and those in the left-hand range are substantially the same, excepting that the lamps are fitted with enamelled steel reflectors of the so-called "45 degrees parabolic" type with frosted aluminium interior surfaces. The lamp spacing and curves of illumination along the bullseye lines for the four sets of targets are shown in Fig. 2. It will be seen that in both ranges the upper row of targets is better lighted than the lower one, and that the metal reflectors give a marked advantage in the matter of uniformity of illumination. The curves A and B could, without doubt, be raised considerably by cleaning the glass reflectors, and the writer was indeed told by

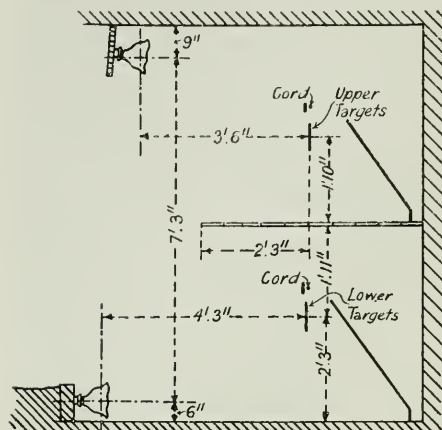


FIG. 1.—National Reserve Rifle Club Ranges.
Disposition of targets and lamps on right-hand range.

extends outwards sufficiently to prevent any light from the ceiling lamps from reaching the lower row of targets or

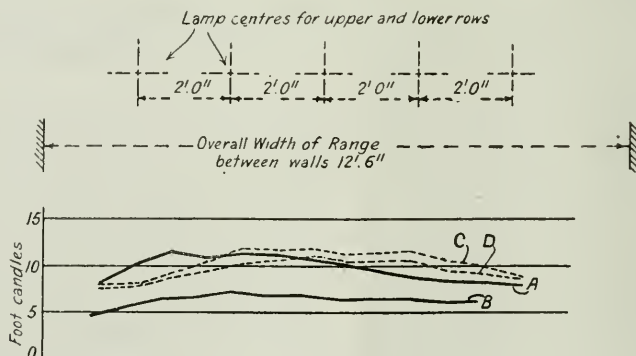


FIG. 2.—National Reserve Rifle Club Ranges.

Curve A = Illumination on upper targets of right-hand range.
 " B = " " lower " " " "
 " C = " " upper " " left-hand "
 " D = " " lower " " " "

light from the floor lamps from reaching the upper targets. There are five lamps in each row, varying from 40 to 60 watts, spaced two feet apart, and fitted in the case of the right-hand range with pris-

matic glass reflectors. At the time when the tests were made, these reflectors were all very dirty and portions of some had been broken away, no doubt by ricochet bullets. The middle lamp of the lower row was entirely without a reflector.

the targets is topped with a thick layer of dust which lodges freely on the lamps and reflectors under the action of the lead splashes, and, for this reason, prismatic glassware of the pattern which has no metal protection over the prisms appears to be inapplicable on this range.

The curves show a declining illumination towards both ends of each row of targets, and this effect, which will also be noticed in some of the curves which follow,

of which has been blackened. Before this blackening was employed, trouble was experienced owing to sunlight coming through the glass and forming a luminous haze in the smoke which accumulates in the range, but this difficulty disappeared when the glass was obscured. The target chamber is lighted entirely by electric lamps placed as shown in Figs. 4 and 5, in which L¹ indicates the position of three 25 candle-power lamps with 9 in. opal

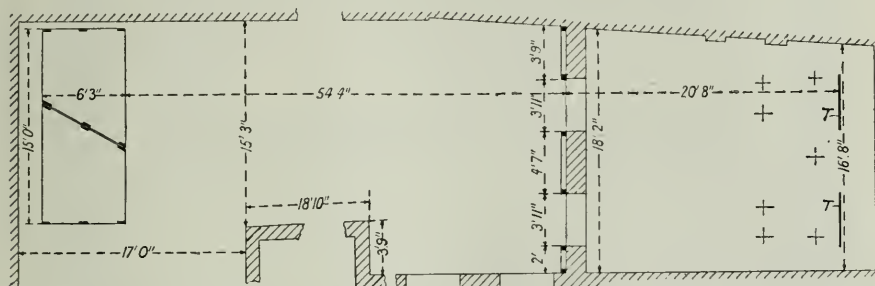


FIG. 3.—Range at H.M. Patent Office. Plan view of range lay-out.

T = Targets. + = Lamp centres.

The firing-platforms are indicated by the obliquely-divided rectangle at the left-hand of the diagram.

is common on ranges lighted by lamps placed in straight rows. With such a distribution of lamps, uniform illumination across the targets can only be obtained by the use of special reflectors or by increasing the candle-power of the end lamps.

Range at H.M. Patent Office.

The structural nature of the basement in which this range is situated makes it a somewhat interesting example. As shown in the plan view, Fig. 3, the targets, T, are placed at the end of a long room which is divided transversely by a brick partition fifty-four feet away from the firing platforms. This partition has two openings, each approximately four feet wide by six feet high, through which the targets are seen, and the front of the partition, *i.e.*, the side facing the firing-point, is faced with blackened wood. The targets are situated in a chamber, about twenty feet long and seventeen feet wide, of which the walls are finished with a pale yellow distemper. Between the firing-point and the partition there are two glazed roof lanterns, the glass

conical reflectors, and L² indicates four lamps mounted on an inclined batten and provided with frosted aluminium and steel reflectors of an intensive type. The two outermost lamps, L², are of 65 candle-power

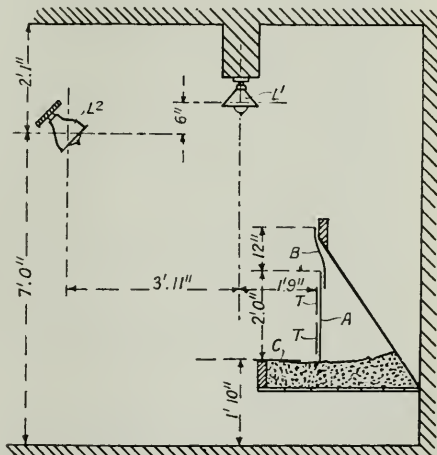


FIG. 4.—Range at H.M. Patent Office, London.

A = Brown millboard. B = Green baize.

C = White card. T = Targets.

L¹ = 25 c.p. lamp. L² = 65 and 100 c.p. lamps.

each, and the two inner ones are of 100 candle-power. The lamps, L^1 , contribute only a small amount to the target illumination, and they are used merely because they happened to be already installed as part of the basement lighting before the

targets, T , are clipped on to renewable sheets of brown millboard, A , above which is a strip, B , of dark green baize about a foot deep. This strip was provided for the absorption of lead splashes, but the fortuitous choice of a green material for

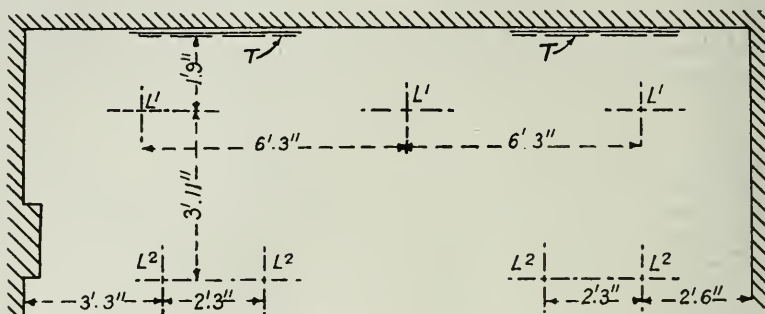


FIG. 5.—Range at H.M. Patent Office. Plan view of lamp and target positions.

T =Targets. L^1 =25 c.p. lamps. L^2 =65 and 100 c.p. lamps.

range was put in. Sheets of white card have been hung on the conical reflectors to assist in directing the light on to the targets, and no portion of any lamp or reflector can be seen from the firing-point. Fig. 6 is a photograph of the targets and lamp arrangement taken inside the target chamber, and the appearance of the

this purpose has led to an interesting transition of surface brightness from the targets to the black woodwork which forms the end of the range and is visible above the green baize. (See Fig. 7.) The ratio of surface brightness for this mounting is as follows:—green baize : brown millboard : white target = 1 : 17 : 40.

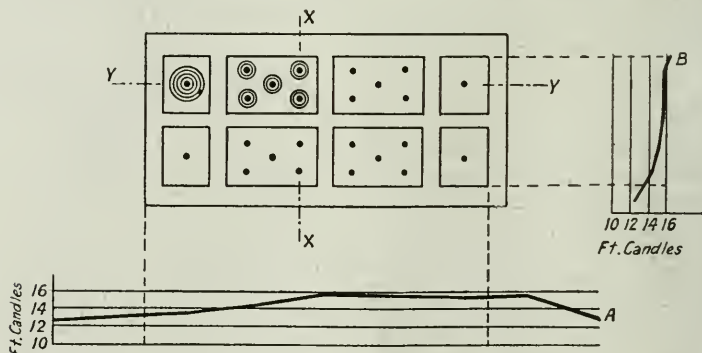


FIG. 8.—Range at H.M. Patent Office.

Curve A=Illumination along line YY. Curve B=Illumination along line XX.

targets as seen from near the firing-point is shown in Fig. 7. (These photographs were taken by Mr. Dow, entirely by the artificial light provided for the range.)

The details of the target mounting are indicated in Fig. 4, and experience has shown that this mounting gives very comfortable aiming conditions. The

To assist the illumination on the lower row of targets, a strip of white card, C (Fig. 4), is laid horizontally on the shingle box, as plainly seen in the photograph (Fig. 6).

The curve A, Fig. 8, shows the illumination along a horizontal line, YY, through the left-hand set of targets, and the curve



FIG. 6.—Range at H.M. Patent Office.
View of lamps and targets at close quarters.

Lumina Bureau Photo.



FIG. 7.—Range at H.M. Patent Office.
View of targets from left-hand firing-point.

Lumina Bureau Photo.

B shows the illumination along the vertical line XX. The target illumination is seen to be very uniform, having maximum and minimum values of 15.6 and 12.8 ft.-

Range of the Central Markets Rifle Club, Smithfield.

This range, which is situated on a roof, is adapted for daylight and night shooting. The firing-point is under cover with bare lamps, well behind the mats, for general illumination, and the targets are lighted by a row of "footlights," as shown in Fig. 9. The row of footlights comprises eight 55-watt lamps mounted under somewhat thick glass bells in cast-iron fittings with inclined elliptic openings. These fittings have an inner surface of poor reflecting quality, and at the time of testing they appeared to function more as a mechanical protection for the glassware than as reflectors.

The space between the firing-point and the targets is bounded by dark wooden walls and has no roof, excepting a series of spaced transverse timbers so distanced as to prevent the escape of stray shots. The targets are mounted against a dark background on four open wooden frames, each carrying targets for two marksmen, as shown in Fig. 10, the frames being coupled together in pairs and connected to overhead winding-cords operated from the front of the firing platform.

The illumination on the two central frames (see Fig. 10) varies from 11 to 12.2 ft.-candles and is fairly uniform, but on the outermost frames it is seen that the illumination falls to nearly two-thirds of the central value.

Range at the General Post Office, St. Martin's-le-Grand.

Like the Smithfield range described above, this is an open roof range bounded

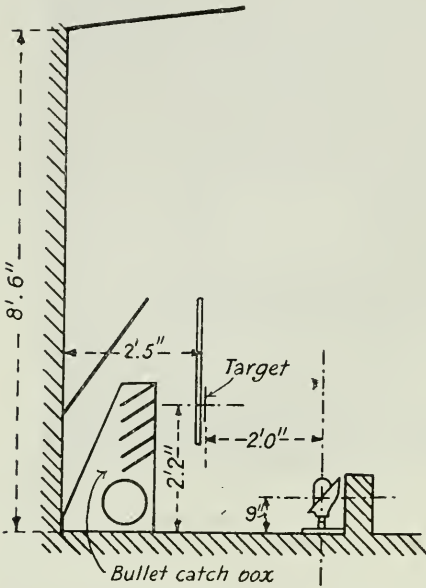


FIG. 9.—Range of the Central Markets Rifle Club, Smithfield.
Disposition of lamps and targets.

candles on the line YY, and 16.1 and 13.5 ft.-candles on the line XX, and there seems little doubt that the uniformity is attributable in great part to the fact that the targets and lamps are placed in an almost completely enclosed chamber having light walls and ceiling.

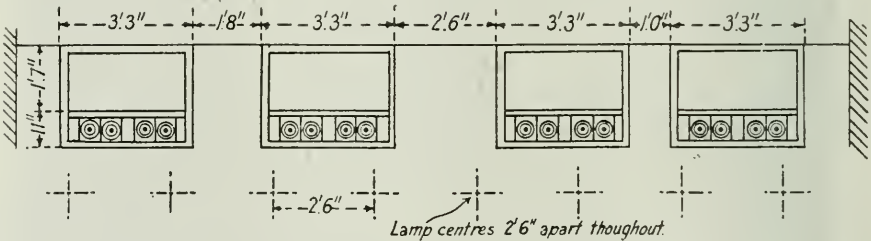
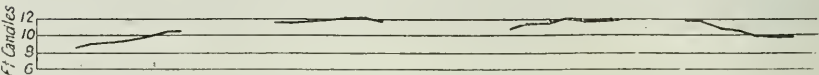


FIG. 10.—Range of the Central Markets Rifle Club, Smithfield.
Curves of target illumination.



by timber walls and having an overhead construction of widely-spaced timber baulks between the covered firing-point and the targets. The targets are mounted in two groups of four behind narrow frames of black wood which protect the target-cords, as shown in Figs. 11 and 12.

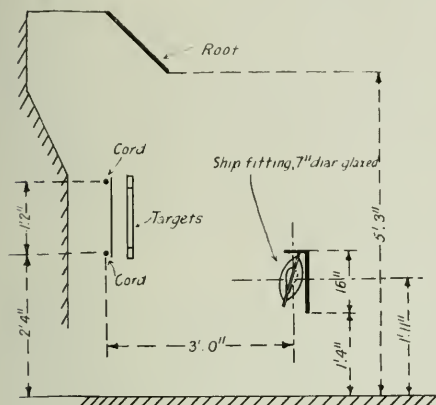


FIG. 11.—25 yards range at the General Post Office, St. Martin's-le-Grand.
Disposition of targets and lamps.

Opposite each group of targets is a row of seven 20-watt lamps mounted in inclined glazed circular ship fittings with concave white enamelled reflectors behind the lamps. The fittings are protected on the firing side by a vertical black board

sixteen inches high spaced well above the ground, as indicated in Fig. 11.

The illumination curve, Fig. 12, shows a characteristic heaping-up towards the centre of each group of lamps and a marked falling off of the illumination towards the left-hand end of the row. This falling-off is partly due to the lamps and fittings on the right-hand side being in better condition than those on the left, but a secondary and no less important cause of the difference is apparently connected with the structure of the range itself. As indicated in Fig. 13, on the right-hand side the wooden palisading which forms the walls of the range is carried on to meet the back wall behind the targets, whereas on the left-hand side there is an opening in the palisading adjoining the targets. This opening leads into another range which is dark at night time, so that the opening forms a non-reflecting surface. The palisading of the right-hand wall, however, although dark yellow to brown in tint, undoubtedly contributes to the illumination of the right-hand targets by reflection.

An Army Range in Surrey.

This range, which is used for daylight and night firing, is, in effect, a long rectangular tube of brickwork and concrete 12 feet wide and 8 feet high with two glazed roof lanterns at the ends, over

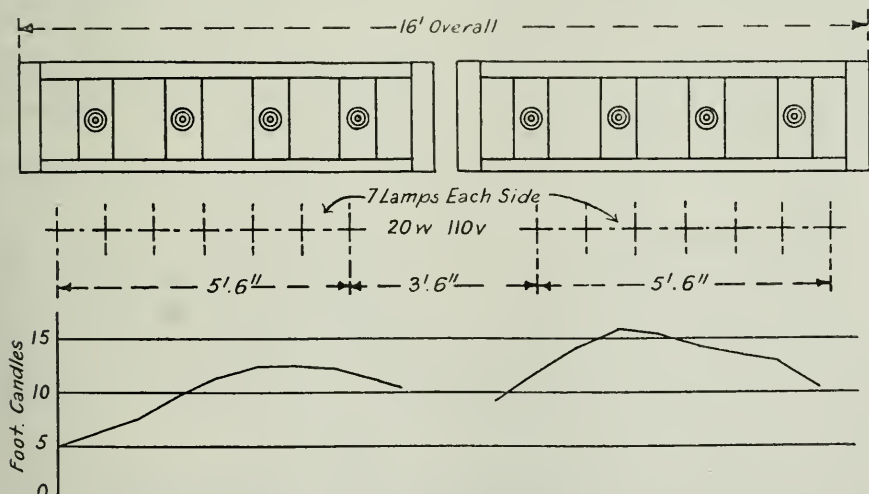


FIG. 12.—Range at the General Post Office.
Curves of target illumination.

the firing platform and the targets respectively. The walls and ceiling are white-washed along their whole length and the targets are backed by a stack of tarred road blocks.

the test was made without altering the setting of the batten from its usual service position. In the extreme left-hand holder there was a 40-watt lamp, and in the three others 60-watt lamps. This asymmetry

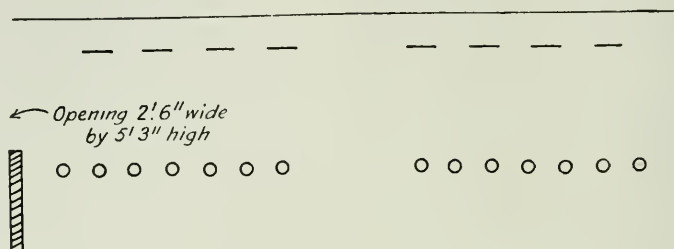


FIG. 13.—Range at the General Post Office.
Sketch plan of lamp and target disposition.

For night shooting, a transverse batten with four electric lamps is used, as shown in Figs. 14 and 15. The lamps are contained in downward-pointing, trumpet-shaped, cast iron reflectors, originally having a white enamelled inner surface but now very much discoloured. The

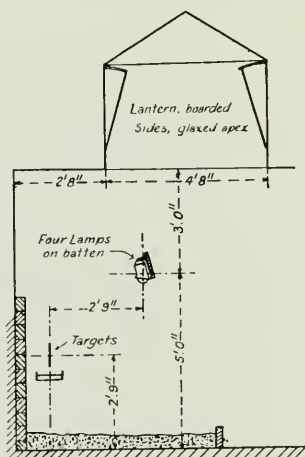


FIG. 14.—An Army range in Surrey.
Disposition of targets and lamps.

batten is supported at each end in a grooved block on the wall, and it was noticed that by rocking the batten in the grooves the target illumination could be varied considerably. The position normally assumed by the batten throws too much light downwards and thus does not make quite the best use of the lamps, but

of the lamps accounts for the depression of the illumination curve towards the left-hand targets, Fig. 16. The range is adapted to take three targets abreast, equally spaced between the lamp centres, but when the test was made four targets were being used, approximately opposite the lamp centres as shown. By interchanging the first and third lamps, counting from the left-hand end, it is evident that the illumination on the targets could be rendered considerably more uniform. No opportunity for trying this was available, however, at the time when the range was being tested.

The overhead lamps, A, were not in use, and the firing-platform was lighted entirely by the pendant, B. There was no sign of glint on the sights and the general illumination on the platform appeared to be just adequate.

Ratio of Maximum to Minimum Illumination on Targets.

In the foregoing description, it will be noted that the ratio of maximum to minimum target illumination has widely varying values, and the question naturally arises as to what limiting value should be allowed for this ratio. In Figs. 8, 10, 12, and 16, the values are approximately 1·2:1, 1·32:1, 2·66:1, and 1·44:1 respectively.

Inquiry sometimes shows that there are favourite places on the mats of a given range and the favourite places may be those commanding the best lighted

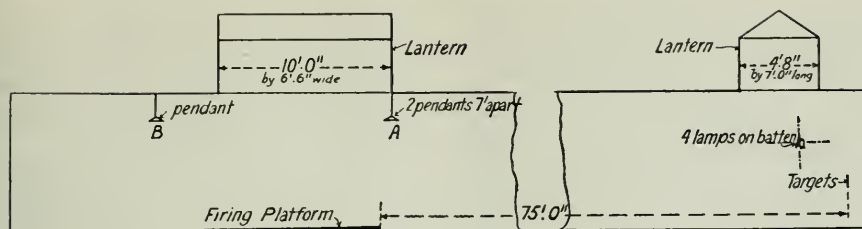


FIG. 15.—An Army range in Surrey. Longitudinal section of range.

targets, or at any rate those which are not allotted to the worst lighted targets. Among the examples shown above, however, the writer could not find definite

"unshootable." The visual impression given by these ranges certainly did not suggest the large variations of lighting which the photometer subsequently revealed and the general conclusion was arrived at that none of these ranges could be regarded as having intolerable differences in the illumination of its targets. Accordingly it would appear that good aiming is not prejudiced anywhere on a range if the ratio of maximum to minimum illumination on the several targets is not much greater than 2.5 : 1.

An example is shown in Figs. 17 and 18 in which the ratio is 3.5 : 1, and it was evident at the first glance that the end and centre targets on this range were of little use. The range is used by a voluntary training corps and is lighted by two 3-mantle inverted incandescent gas lamps placed behind iron screens, as shown in Fig. 18. The screens were originally whitened behind the lamps, but at the time of testing they were soiled and of small reflecting value, in addition to which one mantle in each lamp was not glowing owing to faulty adjustment of the lamp. A great deal of the light was thrown vertically

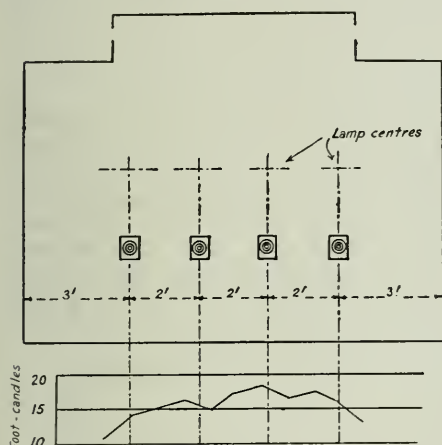


FIG. 16.—An Army range in Surrey.

Transverse section of range and curve of target illumination.

evidence that any of the targets were generally considered by the users of the ranges to be so badly lighted as to be

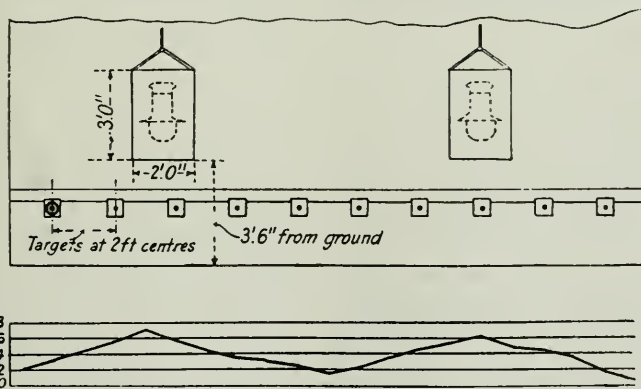


FIG. 17.—A range having a high ratio of maximum to minimum target illumination.

downwards on the ground in front of the targets, and there is no doubt that if the six mantles were redistributed along the

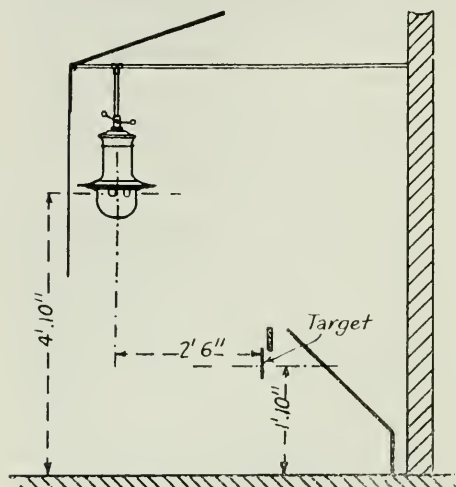


FIG. 18.—Disposition of lamps and targets in range shown in Fig. 17.

range and provided with reflectors of a proper characteristic the twin peaks could be removed from the illumination curve

for rapid fire—it is desirable to make provision for altering the illumination at will. This may be done by altering the position of the lamps or by providing extra lamps which are only employed when coloured targets are in use.

A simple arrangement for enabling the lamps to be moved is shown in Fig. 19. The device is used on the range of a well-known regiment having its headquarters in London. The arrangement is shown in section on the left-hand side of the figure and in front elevation in the upper part of the right-hand side. The targets are hung from a cord in front of a vertical board of pale green tint and another board having the same colour and a black upper margin is placed in front of and above the targets. Electric lamps are spring-mounted on the front of a series of spaced wooden box-like structures, five of which are joined together by a vertical strip of wood, as shown in plan at the lower part of the right-hand side of the figure. The boxes contain diagonal steel plates for deflecting stray bullets downwards. Behind each lamp is a concave glass mirror loosely

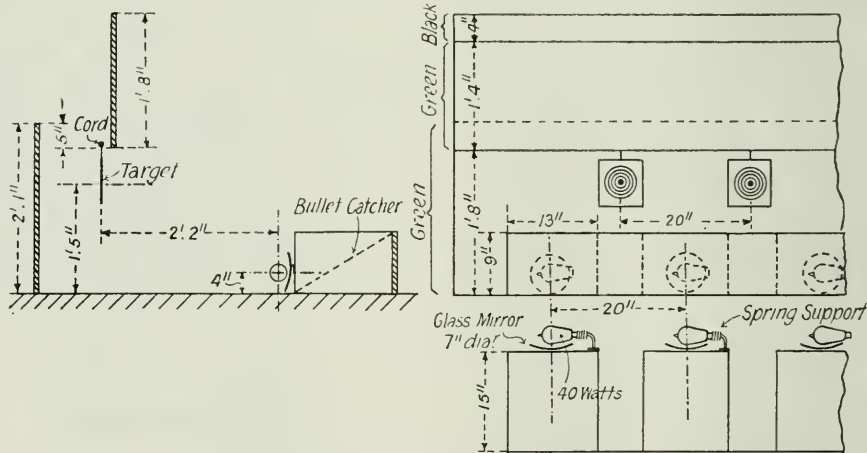


FIG. 19.—An arrangement of lamps for giving adjustable target illumination.

and the illumination along the whole row of targets could be much increased.

Adjustability of Illumination on Targets.

In the majority of ranges, the illumination on the targets is of fixed value, but where targets of different natures are employed—say white targets as an alternative to figure targets or green targets

held by a clip in a socket on the front of the box. Connection to the electric supply is made through a plug and flexible cord, and the whole assemblage of boxes, lamps, and reflectors may be placed at any desired distance from the targets. In addition, the illumination on the individual targets may be controlled by tilting the reflectors with regard to the lamps.

Mr. A. SCHAMASCH said the main object of training on a miniature range was to train the nerves and muscles so that they were subjected to the eye. This, and the correct method of aligning the sight on the mark, were the two important factors in musketry. He believed in eliminating troubles as much as possible from the start; consequently a recruit should commence on the simplest form of target, that is the bullseye, and one should put into his hands the finest kind of sight possible for such a target, which in his opinion was the aperture. A recruit should next become proficient with a service sight on a bullseye target, and finally he should proceed to work on a target more nearly approaching service conditions (such as a picture of a khaki figure lying on a sky line between a bright green ground and a grey sky). In using figure targets, great care must be taken in the illumination. He had seen one range in which such a target was illuminated by a dirty metal filament lamp, under-run, and it was almost impossible to distinguish details on the target, the colour of the light being so yellow as to make the whole thing one blur. With an ordinary tungsten lamp of sufficient voltage much better results were obtained.

With regard to miniature ranges and the imitation of outside conditions, he had never seen one in which this was done. Mr. Trotter's arrangement at the Charing Cross range was probably the nearest approach to an open-air range. As to lighting the firing points, in his opinion the only admissible form of illumination would be completely indirect. It was true that in the open-air the sun shone on the back sight, but there were such different conditions that it was not at all fair to draw a comparison between this and the illumination at the firing point of a miniature range. Any bare light on a range at the firing point gave a line on the top of the back sight and produced fringes which were not solely due to out of focus effects. With indirect lighting this effect would be negligible.

Added:—

In view of the arguments of subsequent speakers I should like to add the following statements.

Several speakers maintained that the authorities were wrong in not equipping all rifles with aperture sights. Their experience, I believe, is limited to the bullseye and figure target. If, however, the aperture, as at present made, were tried on real service conditions, that is on a khaki figure lying under cover in an actual landscape, I do not think it would be satisfactory.

It is extremely hard to see a man, lying still, even with the naked eye. If now an aperture smaller than the pupil of the eye be introduced the light reaching the eye will be reduced, and it will be found that the colours are less vivid. I do not think it would be possible to find the man through the aperture. In case of open sight no reduction of light at all takes place above the bar, so that the method used is, keep objective in view and bring sights *up* till they are aligned on it.

Another speaker mentioned that for long range (16,00—2,800 yards) an aperture sight of sorts was fitted to rifle, and he used this as an argument that the authorities saw the advantage of this sight.

There are two reasons why an aperture is fitted in this case.

Firstly, it would be impossible to fit any kind on top of the barrel as the neck is stretched to a most uncomfortable extent when sighting up to 1,600, and though the ordinary sight is graduated to 2,000 nearly all people prefer the comfort of the aperture sight. The second reason is that for ranges above 1,600 it is quite certain that the aiming mark will never be a man or horse, and so it will only be used for aiming at a suitable landmark or feature of the ground. There is then no reason why such a landmark should be small, and it will probably be easy to select a large enough mark to be clearly visible through the aperture. Moreover, the long range fire is only used by considerable bodies to cause a danger zone and it is only the collective effect that is required rather than individual accuracy.

Another point regarding my argument about a line of light was the question of blacking the sights. Such a proceeding is forbidden by the regulations as being quite impracticable on service. The

surface of the sight is blued steel and should be used as issued.

Mr. P. J. WALDRAM said he had some small experience of miniature rifle ranges some years ago in conjunction with training recruits for the service rifle. In those days the miniature range consisted simply of an ordinary drill hall without any special illumination. It was found that if they could get the men up to Morris tube practice with the ordinary service rifle during the early months of the year, there was no difficulty in turning out creditable shots before the middle of the summer. He had also found that it was practicable to predict from a man's progress at the Morris tube range what he would do in the open. The lighting of the range usually was simply a series of unscreened arc lamps at the top of the drill hall. He had found, however, that when a smaller range was used, viz., a gallery which was screened from the general lighting of the hall and was locally illuminated in order that the targets might be seen, the majority of men would not shoot there under any circumstances.

As to glint on the back sight (which easily rubbed bright) many men at open-air ranges carried a box of wax vestas so that they could smoke the back sight or, more often, the fore; and some shots carried a box of black paint with them. The army musketry instructors always impressed the importance of a man training himself in the holding of a rifle at any odd moment at home. There was far more bad shooting through a man coming to a range with his muscles improperly trained for holding the rifle than from any errors in sighting.

Another curious thing he had noticed in open-air ranges was that some men shot well when the targets had been washed by rain and badly splashed by the clay soil splashing up on to the targets, although they were firing at a green-brown mass and merely had an idea that there was a bull somewhere about the middle. Even men shooting in wind and rain under these conditions could put up good scores simply because their muscles were well trained for hold-

ing the heavy rifle and they were able to pull off steadily whenever they wished.

Mr. H. BRAZIL said that being the Secretary of a Club having three ranges, he was very interested in this subject. The lighting of one of these ranges had been subject to a considerable amount of alteration since it was opened, at first one 50 c.p. lamp for each target was arranged on the floor about 3 ft. from the target with a reflector inclined slightly upwards was employed. Difficulties were at once experienced owing to the fact that the targets being attached to clips which were in turn attached to a wire rope did not always hang vertically, and when they tilted forward the illumination was very much reduced; to get over this difficulty and to get a more brilliant illumination (this being called for by the members) another 50 c.p. lamp was placed at each point slightly above the target and about one foot from it, this quite got over the difficulty of the targets tilting and, although some members have complained that there was too much glare, some very good shooting with orthoptic sights had been done at this range; on the other hand, he was inclined to think that the amount of illumination is too much for open-sight shooting.

He quite agreed with one of the other speakers that the conditions should be made as easy as possible for the beginner and that he should be allowed to start with orthoptic sights, the targets having the maximum amount of contrast between the bull and the card. By starting in this way the beginner would be quickly taught to aim properly, as he could see both fore sight and bull clearly with the orthoptic sight and he would be able to judge from the results obtained whether he had been holding the rifle steady.

He was also quite in agreement with another speaker in advocating the use of the orthoptic sight in actual warfare; it was acknowledged everywhere that shooting with orthoptic sights was 30% to 50% more accurate, and with such a resourceful enemy against us we could not afford to throw away such an advantage. Mr. Trotter had mentioned that for the efficiency test in Volunteer Training Corps the open sight was insisted upon

and apparently nearly all the shooting in these corps was done with the old form of "V" back sight which was from 3 to 5 m/m across the top. The back sight fitted in the latest Service rifles was of a "U" shape and only 1 m/m across the top which made it much easier to get the top of the fore sight on a level with the sides of the back sight as these were not off the edge of the card. He had had these back sights fitted to rifles used by members of his club and the improvement in the shooting was very noticeable.

With regard to the question of dark or light backgrounds for the targets, he was of the opinion that for orthoptic sights the dark background was a distinct advantage and the very high scores that were made on ranges with dark backgrounds confirmed this opinion. On the other hand where open sights were used he was not sure which was the better, and would prefer to keep an open mind until he had made further experiments.

In his opinion the use of a telescope to spot each shot was very essential, especially for beginners; it was useless for a man to fire off ten shots without knowing whether they were on the target until he had it returned to him.

Mr. Trotter had that evening very clearly explained and illustrated an experiment in the lighting of Rifle Ranges which he (Mr. Brazil) had had the pleasure of rigging up. Unfortunately, it was not possible to get this going until just a day or so before the meeting so that the time for experimenting was short. He had, however, induced several men to try the range and they all, without exception, had no hesitation in stating that they could see the back sight and fore sight much more clearly than was the case in a range where the firing point was kept dark. The scoring on this range with open sight rifles was, in some cases, markedly better than on the ordinary range. He ventured to suggest to Mr. Trotter that it might be an improvement if the lighting was graduated, the screen nearest the firing point having, say, two lamps, the middle screen four, and the target six or eight. He thought that Mr. Trotter was working in the right direction in attempting to imitate open-air conditions, especially as the real

shooting would have to be done under these conditions.

Col. GAITSHELL BURR said that his personal experience of miniature ranges in London was that they were not sufficiently well lighted, but whether that was due to defective sight, he did not know. In some cases he found it difficult to see through the back sight properly. Some ranges are better lighted than others, but there should be special illumination of the whole range in order to make good practice.

There is also room for improvement in other ways, such as painting the surroundings white and keeping the lamps thoroughly clean, especially at the firing point.

Mr. FREAK, speaking with regard to the Charing Cross Range, suggested that a similar contrast between the target and the background might be obtained by putting the target against a light background instead of a black one, and doing away with the screens altogether.

Mr. W. J. BASSETT said he had done a good deal of shooting at miniature ranges during the past six years, and agreed that the use of the orthoptic sight was essential to good shooting. He could not understand why such great efforts should be made in making the rifle such a scientific weapon, and yet the facilities for using it were of the same nursery type as they were many years ago. This was singular, because he understood that some orthoptic sights were being used by sniping men at the front. It was also a fact that many men at the front, who were old Bisley shots, took their orthoptic sights with them, and their officers were giving them every encouragement to use them. They could be fitted to the service rifle without difficulty, but the authorities had never given facilities to rifle makers and sight makers to attach them properly to the service rifle. Similar proof that the authorities really recognised the advantages of the orthoptic sight was that the Mark I. rifle used in the South African War had this sight. With the use of the ordinary open sight, valuable time was lost in firing.

With regard to lighting the firing point, the difficulty was that if a light was behind, it was not in the right place, whilst if it was in front or on the right or left, it caught the eye. Semi-indirect lighting all round was an improvement. The closest imitation of daylight he had seen at a miniature range was at the Royal Automobile Club. The background was green, and there was a row of incandescent lamps at the bottom with arc lamp at the top, and the combination of the two produced a very bright light, but it was a very difficult range to fire on.

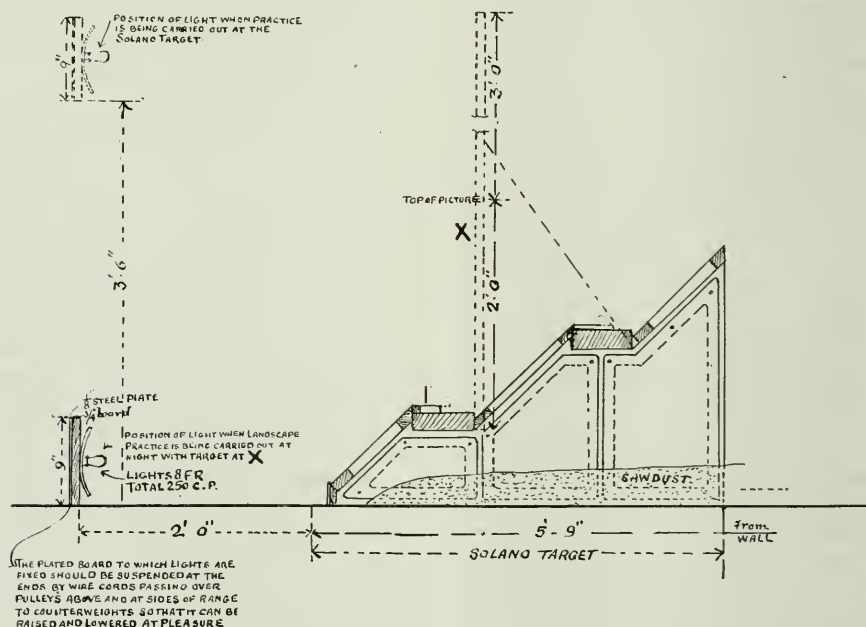
Mr. G. HERBERT referred to one of the pictures shown on the screen and stated that it was the rifle range of the Guildhall Athletic Club (Corporation of London); the illumination was 10 to 12 foot-candles and this result was obtained by using steel reflectors parabolic type 45° .

A double row of targets are used, being placed 2 ft. apart and approximately 2 ft. 6 in. from the ground and the same distance from the ceiling, and consequently the reflectors illuminated the targets with a direct ray at an angle of 45° from the vertical.

THE COMMANDANT OF THE ROYAL SCHOOL OF MUSKETRY, HYTHE (communicated) :—

OBSERVATIONS ON ARTIFICIAL LIGHTING OF MINIATURE RIFLE RANGES.

On miniature ranges the most suitable method of illuminating the target is to provide a number of incandescent gas, acetylene, or electric lights fixed to a $\frac{3}{4}$ in. board suspended horizontally by flexible wire cords at each end, and faced with pieces of $\frac{1}{8}$ in. steel plate in front of each lamp. The wire cords should be



These reflectors were attached to ordinary batten holders, 2 ft. apart, fixed to a movable frame and placed at a distance of 2 ft. 6 in. from the face of the target to the centre of the filament of the lamp, the object of the movable frame being to vary the illumination according to the style of target being fired at.

carried over pulleys fixed to rafters or ceiling above and thence over other pulleys at the sides of the range, to counterweights heavy enough to balance the weight of the board, &c., and allow of it being moved up and down by hand, to suit the various positions of the targets. The positions proposed for the lights on a range fitted up with Solano and land-

scape targets are indicated on the accompanying print.

For the upper positions it may be necessary to arrange to tilt the board so as to throw the light down on the targets, and the protecting steel plates should therefore be deep enough to protect the lights even when the board is tilted.

In the case of gas a flexible length of tubing is required from the suspended board to the nearest point of the fixed gas pipe, and with electric light, a length of double insulated wire is needed.

To keep down the weight as much as possible, the length of the board should not extend beyond the targets to be illuminated, and when a 10 feet Solano target is used, the lights should have a total of about 250 candle-power and be fitted with good reflectors.

No specially powerful illumination is needed at the firing point, where one or two ordinary lights should suffice, as it is found that many men when firing prefer the lights near them, turned down or extinguished altogether.

MR. FRANK BAILEY (*communicated*):—The utility of miniature rifle ranges is now so recognised that it seems incredible that only a short time ago it required the powerful assistance of the late Lord Roberts to obtain official sanction for the adoption of this method of teaching Young England to shoot. Many Army authorities now agree that 75 per cent. of all there is to be taught in shooting is capable of being learned on a miniature rifle range. The knowledge of how to handle a rifle, aim and fire correctly, is so important that although the indoor ranges do not in any way attempt to reproduce practical conditions the result of the movement has been most beneficial. During the last year I have had the opportunity of forming this opinion as the result of establishing a miniature rifle range with about 250 members.

Mr. Trotter has opened the discussion on this subject so admirably, and speaks from actual experience, that I can proceed at once to matters of detail.

An indoor range cannot of course reproduce the actual conditions of wind and light variations, but an open miniature range of, say, 100 yards can give experience in these matters.

The lighting of an indoor range is an easy matter to carry out, and it does not seem necessary to limit the illumination provided it is well diffused and there are no harsh lines or brilliant beams of light.

A target with a black bull on a white ground is easier to hit than a white bull on a black ground.

In using the orthoptic sight most shots prefer to have the firing point dark, but with open-sight it is essential to have light at the firing point in order to be able to see the sights of the rifle.

If the range is dark, with the exception of the target, we have found that sources of light should be screened from view in order to prevent distracting rays from crossing the line of sight, and in illuminating the target it is better to place the source of light below the target, thus throwing the light upwards.

As regards the use of the orthoptic sight, it has been stated that this results in a 10 per cent. improvement in shooting, and the attachment which is now made in a handy form by The Birmingham Small Arms Factory does not appear to be very much more fragile than the existing sights; we can, therefore, hope that the authorities may eventually recognise and approve of the use of the orthoptic sight.

It has always seemed to me that the miniature range has suffered from the erroneous impression which many people seem to have that it is a sort of toy, and does not reproduce practical conditions. The use of small and light rifles possibly gives some ground for this impression, but if we can practise with full size service rifles (but with a small bore) and preferably with bayonet attached, we not only get used to the actual weight of a rifle but the shooting is also improved, the only thing missing being the "kick" which is so often found with unpleasant results when service ammunition is first tried on an open-air range.

The physiology of the eye, and the difficulty many people find in adjusting their eyesight, is very clearly explained by Mr. Trotter, and I venture to think that some of these difficulties can be realised, and to some extent overcome, by practice, by experimenting with ordinary dioptric prismatic binoculars with adjustment for each eye; then, by looking at an object with one free eye

and the other through the field glass, it will be found that although at first there is some difficulty in obtaining the necessary muscular control independently of each eye, yet with a little practice this can be accomplished, and the rifle can then be handled with more confidence without the necessity of screwing up one eye and suffering from a sort of astigmatism.

The present war is apparently showing that the firing distance is frequently as short as 200 yards, and there must therefore be some difficulty in getting the shots low; but as the bayonets are always fixed perhaps this will keep the muzzle down.

Any pastime or work which improves efficiency must clearly be good, and I can testify to the fact that the use of an indoor miniature rifle range has great possibilities in improving physique, methods of breathing, the use of the eyes, and general steadiness. We all know the story of the young recruit who, when taken to the butts, was directed by his sergeant to fire at 1,000 yards, with no apparent result; he was then taken to the range at 500 yards, still with no result; then at 200 yards with no hit, and on the range being shortened to 50 yards without result, the by that time exasperated sergeant yelled, "Fix bayonets and *charge*—for that's the only way you'll get there."

Mr. SYDNEY G. CORAM, Instructor of Musketry (*communicated*):—This is a matter in which I am very much interested, as I have always felt that miniature ranges are very badly lighted.

I am strongly opposed to all the light being thrown on the targets, and the firing point kept in the dark, because this is directly opposite to ordinary conditions.

I would suggest where it is possible, that a miniature range should be fitted with hidden lights both sides of the range about 12 inches from the ceiling or some similar arrangements of diffusing light as near as possible to daylight. I am of opinion that every opportunity should be taken to teach and correct the method of holding a rifle, aiming and firing on the range; of course, I am speaking from a strictly military value point of view, and feel that all the conditions

should be made as near as possible to those under which men would have to fire when on active service.

I have continually found that men who have been used to miniature ranges where the firing point is kept dark, have shown considerable difficulty in getting correct aim upon their first appearance on an open range, and invariably complain that the light on the foresight or backsight blurs their visage.

I don't think there are any other points that I desire to put before you, and must express my regret on being unable to attend your meeting.

Mr. T. BERNARD PICKARD (*communicated*):—Personally I consider that there is undoubtedly a degree of illumination of the target which gives the best definition of the bull.

I strongly believe in a neutral background to the targets preferably tending to green and fairly illuminated, and, of course, the sources of light concealed.

The firing point, I consider, should be illuminated, but by diffused *reflected* light the source again being screened (otherwise I think a darkened firing point is preferable to direct sources of light).

Under these conditions I think that an artificially illuminated range may offer opportunities for practice in no great degree less than those available in an open-air range.

Mr. J. G. CLARK (*communicated*):—

SOME EXPERIMENTS MADE ON THE RANGES OF THE GAS LIGHT AND COKE CO.

As bearing on the question of the relation between intensity of illumination of targets and accuracy of fire, I thought an account of some observations and experiments bearing upon certain practical phases of the problem might be of interest. It is realized that they only touch the fringe of the question, but so far as they go they throw some light on certain aspects.

Two experiments on a 25 yards range were made with the following results.

Six targets, the surface brightness of which differed from 4.5 to 45 foot-candles, were fired at by each of six firers, each firer firing ten shots at each target. The following scores were recorded:—

Targets (25 yards range).

Firer.	No. 1. 4·5 ft.-candles.	No. 2. 7·5 ft.-candles.	No. 3. 16·5 ft.-candles.	No. 4. 20·0 ft.-candles.	No. 5. 40 ft.-candles.	No. 6. 45 ft.-candles.	Total scores.
A ..	92	92	87	91	86	91	539
B ..	94	93	95	95	91	93	561
C ..	87	88	86	90	86	89	526
D ..	86	90	81	90	90	91	528
E ..	89	100	95	98	96	93	571
F ..	91	85	83	92	90	90	531
Average	89·8	91·4	87·8	92·6	89·8	91·2	90·4

The aiming was throughout corrected by telescopic observations of the targets.

At the end of this experiment five men expressed a strong preference for No. 4 target and one for No. 3. It will be observed that the highest total score was made on No. 4, although this was not known when the men expressed their preference for this target, but the maximum and minimum totals differ only by about 5%, so that no very fine distinctions can be made.

In the second experiment the conditions were the same, except that the aiming was not corrected by telescope, the

firer being advised of the position of his *first shot only*, the idea being to eliminate any possibility of the firer automatically and deliberately correcting for erroneous aim. It was thought that this procedure would have given a more reliable idea as to the pure question of visibility; it is *not* suggested that correction in practice should *not* be made; on the contrary, the firer should I think be trained to make proper allowance for errors due to light just as he must acquire the habit of making allowances for wind, etc., and should therefore be advised as frequently as possible of the placing of his shots.

The following is a record of the results :

Targets (25 yards range).

Firer.	No. 1. 4·5 ft.-candles.	No. 2. 7·5 ft.-candles.	No. 3. 16·5 ft.-candles.	No. 4. 20·0 ft.-candles.	No. 5. 40 ft.-candles.	No. 6. 45 ft.-candles.	Total scores.
A ..	93	91	97	91	87	88	547
B ..	92	91	83	89	89	94	538
C ..	98	87	88	93	92	83	541
D ..	90	95	96	98	99	92	570
E ..	88	86	95	83	87	83	522
F ..	85	90	93	89	93	92	542
Average	91	90	97	90·5	91·2	90·3	90·6

The aiming was not corrected by telescopic observations.

Here the difference between the maximum and minimum scores is less than 4%, so that it seems safe to infer that within these particular limits of target brightness the visibility is the same. The targets were of the circular type with black rings and bull on fairly white cards. Below is given an account of two experiments on 50 and 100 yards ranges, under artificial lighting, the sources being com-

the conclusion arrived at from the experiments at 25 yards—namely, that within the limits of 6 and 40 foot-candles (surface brightness of white part of target) there is no appreciable difference in visibility. It is interesting to note, however, that something between 10 and 20 foot-candles had almost unanimous approval. Anything higher than 20 was regarded as dazzling, the surroundings being dark in every case.

It is not unlikely that a closer examina-

Target (50 yards range).

			No. 1. 6 ft.-candles.	No. 2. 40 ft.-candles.	No. 3. 17 ft.-candles.	No. 4. 10 ft.-candles.	No. 5. 17 ft.-candles.	
A	..	..	92	91	90	91	93	457
B	..	..	85	88	92	85	90	440
C	..	..	92	95	92	94	91	464
D	..	..	98	99	96	99	96	490
E	..	..	94	94	97	93	90	468
Average	..		92.2	93.4	93.4	92.4	92.4	92.7

Target (100 yards range).

Firer.			No. 1. 3.5 ft.-candles.	No. 2. 8.0 ft.-candles.	No. 3. 13.5 ft.-candles.	No. 4. 6.0 ft.-candles.	No. 5. 9.2 ft.-candles.	Totals.
A	..	..	91	91	94	93	89	458
B	..	..	94	90	93	88	96	461
C	..	..	95	91	92	94	96	468
D	..	..	89	89	90	95	87	450
E	..	..	85	82	89	90	85	431
Average	..		90.8	88.6	91.6	92.0	90.6	90.7

pletely screened from the firers and the target surroundings being practically black.

The firers in each case were advised of the position of their first shot only.

From the scores it appears that the experiments at 50 and 100 yards confirm

tion of the targets might disclose certain differences. For instance in reckoning the scores, a score of say eight at the top of the target is taken as of the same value as eight at the bottom, although their actual positions on the target were of

course some distance apart. Should any member be sufficiently interested I should be pleased to lend him the targets to enable him to make a closer analysis.

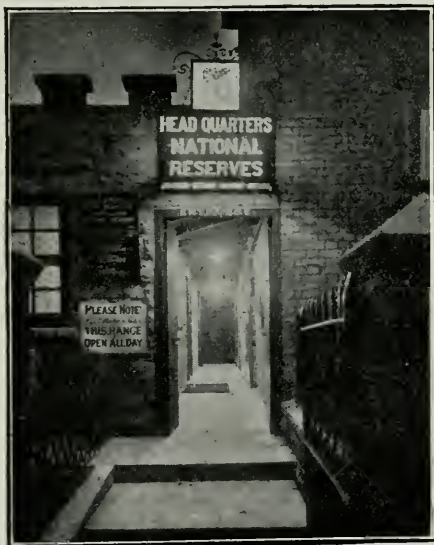
had experience on open and closed ranges, there does not seem much in it. It seems that proficiency at one means proficiency at the other. This perhaps is not surprising when we remember the wide range



Views of gas-lighted ranges. (The light hanging from the roof is screened when firing is going on.)



Showing central control of all lights in the instructor's office by means of chains beside table.



Use of gas-lighted signs outside the range.

Photographs of Gas-lighted Range. (Mr. J. G. Clark.)

It might seem as though the use of targets artificially lighted with dark surroundings introduces a condition which does not exist in practice, but from inquiries I have made of men who have

of adaptability of the human eye, and the further fact that illumination is only one factor of many that contribute to the accuracy of the firing, some of the more important of the others being, the use and

adjustment of sights, the art of trigger pulling, and the steady handling of the rifle, to say nothing of instruction in the general care of the weapon, all of which can be efficiently taught at closed ranges with artificial lighting.

In conclusion I have to acknowledge the assistance of the Gas Light and Coke Co. for the use of their ranges for these experiments, and also to the firing parties who so kindly placed their services at my disposal.

Dr. W. ETTLES (*communicated*):—The first phenomenon mentioned by Mr. Trotter is one which, as yet, has had very scanty attention given to it, and seems to be unknown to many writers on physiological optics. So much is dealt with on the assumption that an out-of-focus image of a luminous point is “a diffusion circle,” basing our calculations and constructions on the result of optical bench experiments, that the fact that the image formed on the retina is produced by refractive media quite different from any dead or inorganic substances is ignored. Yet the reader of the paper tells us very clearly that it is not so much a blurred image which annoys him as “multiple and uncertain images.” Two writers only have dealt with this “polyopia monocularis” of the *normal* eye as something requiring careful study—Prof. Tscherning and the late Mr. Shelford Bidwell. Both agree that they are caused by the sectors of the crystalline lens having different refractive indices and by the fibrous structure being developed as age advances. Bidwell’s experiments, by which he reproduced multiple images by the interposition of a gauze screen in front of the lens, are most instructive.

That shooting taught in an indoor range cannot make the learner accustomed to allow for the effect of wind, quivering haze, density of atmosphere (a Bisley shot alters his elevation with the barometer) and the like, is self-evident: he cannot learn to judge distance, half the battle in individual shooting, and might degenerate into a mere show performer with a pea rifle; in spite of all this, practice at the miniature range is of the utmost value in laying the foundation of a marksman’s education.

Aiming demands a swift to and fro accommodation for, and a maintained impression of, the several sights and the object. Hence presbyopes are severely handicapped, as the paper shows. The clear perception of a near object varies with its illumination and in presbyopia that is markedly the case, as is seen in the characteristic way in which a person whose glasses are mislaid will take a letter close to a lamp to read it. I have been engaged every Saturday evening throughout the winter in teaching shooting at a covered range, and I found it was only the presbyopes who complained of inadequate illumination of the rifle sights. When a bright cross light was thrown on the position occupied by the firer the shooting of the older men greatly improved, and still more when the lengthening day permitted practice in the open. A pin-hole disc placed in front of the eye is of great help, and I know of no valid reason why it should not be used. After all, older men are learning to shoot with the one object of killing invaders and not of hunting for pots. A pin-hole increases accuracy and lessens ammunition waste. It is not at all necessary to have special “peep sights” fitted, as for match rifles, all that is needed is a little cardboard shade fastened with an elastic band, and bearing in its centre a hole about 1 mm. in diameter.

Irradiation is, theoretically, a factor in diminishing visibility, but practically it is impossible to get sufficient light to cause any sensible encroachment on the official bull’s eye. Its size (2 inches at 25 yards) precludes this. Small black points would disappear under conditions where large discs are not perceptibly affected. I found that if the surroundings were too dark the illumination became annoying by reason of the increased adaptation and retinal sensibility. The result was that a glance at the bright target soon produced a strong negative after image which, being superimposed on the retinal picture, degraded it very much. These after-images were practically done away with by increasing surrounding light and so lessening retinal sensitiveness. The rôle of the pupil is negligible compared with that of the retina. When learners become reliable shots it is important to teach them

shooting at objects under lessened contrast. This is easily done by ordering the firer to wear dark smoked glasses—much less trouble than altering target and lights. Any *naked* light lying within ten degrees of the visual axis causes much complaint from shooters who are always anxious to find some reasonable explanation for a poor score. If the light is brilliant it is impossible to shoot well—indeed, in defensive operations the power of blinding an enemy by direct searchlight is often utilised.

My own experience is that a bright light on the card is essential and that one can hardly have it too bright if the range is generally lighted to a moderate degree. General lighting is necessary to enable men to move safely with loaded arms, to find ammunition and dispose of empty cases, to ascertain if anyone has got in the danger area, &c. For all, and especially for older men, a good cross light should be thrown on the firing position, but the metal sights should be blackened as any bright facet acts as a luminous point. The usual mounting for cards makes it difficult or impossible to see bull's eye shots—those on the white card show up as black spots, but the black apertures on the black disc can scarcely be seen with a telescope. It is often essential that a pupil should know exactly how he has amended a previous aim and the point was got by white-washing the iron back plate and so arranging the light that part of it was used to illuminate this plate. "Bulls" then showed up as white points—"outers" were rendered less visible, but could still be clearly seen. The definite knowledge that he has scored a bull is a great incentive to a beginner to put his best into the succeeding shots.

The List of Queries (see p. 250) was submitted to the COMMANDANT at the DEPOT R.M., DEAL, who writes as follows:—

"The experience obtained at this depot of artificial light in shooting galleries is somewhat limited, as all work in connection with the preliminary musketry training of recruits is done by daylight, and artificial light is only used for the purpose in the evenings.

"In the absence of electric light in our gallery, three incandescent gas burners of 60 candlepower are used, one over the heads of the firers, not screened, and two in front of the targets, one at each side, screened from the firers' view; in addition there is one Welsbach light of 120 candlepower over the centre of the targets in line with the other two lights and also screened from view.

"The answers to the questions in enclosed paper are given below:—

"(1) No. After the first few preliminary practices, when conditions should be as simple as possible, the object should be to reproduce practical conditions as far as possible.

"(2) No; but the object should be to fulfil the conditions laid down in (1).

"(3) Yes, to a large extent. With or without artificial light it is impossible to reproduce natural conditions in a shooting gallery.

"(4) Excessive illumination certainly does lead to irradiation, but it is impossible to say from experience obtained here what the permissible limit of illumination should be.

"(5) A dark background is not used for our targets.

"(6) (a) It improves it. (b) Improves it in most cases. The majority of men prefer to do without the overhead light, but some of the National Volunteers who have been using our gallery recently, and who are, of course, much older men than the recruits, find that they cannot see the sights without the overhead light.

"(7) Yes, certainly after the preliminary practices.

(8) (a) A good alternative lighting arrangement is one in which the lights are at the end of the gallery behind and above the targets, with reflectors throwing the light down on to the targets and at the same time screening the light from the firers. (b) I cannot say.

"(9) Yes. If the ceiling of the gallery were suitable some system of reflex lighting might be tried with advantage.

"(10) No experience has been obtained here."

Mr. FRANK WEST (Hon. Secretary of the Rifle Club at the India Office) (*communicated*):—

The chief object of a rifle range is to afford opportunity to unskilled shots to become good marksmen, and also to give practice to trained shots living in crowded localities (who could not otherwise obtain such practice), in order that their skill may be maintained, if possible, improved.

The ideal light for shooting is daylight, subject, of course, to certain restrictions regarding the position of the sun, &c. In most ordinary basement ranges it is impossible to use daylight, and in certain parts of the year even ranges above ground must be artificially lighted during shooting hours.

The use of artificial light seems to make skilful shooting more difficult, and the difficulties seem to increase with advancing age.

With the open sights there is little or no trouble in daylight, but on an artificially-lighted range one main defect is that the bull's eye becomes hazy and less clearly defined. If there be this difference then the defect is clearly due to the artificial light. In what does the defect consist? Is the intensity of the light insufficient? The defect is generally remedied by the use of a peep-sight which seems to point to the mode of lighting the target, and not the intensity of the light as being defective. On an artificially-lighted range some shooting takes place with a lighted target and utter blackness at the firing point; some shots, however, do not mind their rifles being in the full glare of the light. I have even seen good shooting on a range where the targets were more poorly lighted than the firing point, the shooting taking place in the full glare of an overhead light.

It seems to be generally admitted that keenness of vision is favourably affected by having a dark background to the targets, the source of light illuminating the target being concealed from view.

I am of opinion that if the artificial conditions of lighting could approach those of the open air, then range shooting would reach the ideal stage.

number of rifle ranges in London in connection with this discussion. The usual method of lighting consists in strongly illuminating the targets by concealed lamps, the firing point being left in complete darkness. In general the amount of illumination on the target appeared sufficient, readings from 8—15 ft.-candles being recorded. I have been told of provincial ranges where the artificial lighting was much less satisfactory, *e.g.*, the use of bare lamps at intervals down the sides of the range or of naked flickering gas-jets, the burners of which obviously needed attention. It will be generally agreed that marked defects of this kind should be avoided.

On one range visited it happened that, owing to derangements in the lighting, three successive targets had illuminations of approximately 10, 20, and 50 ft.-candles. My impression of the effect in this case bears out the view expressed by Mr. Blok and Mr. Clark, that 20 ft.-candles is ample for ordinary targets, and 50 ft.-candles excessive.* Certainly the white background on the target receiving 50 ft.-candles appeared to encroach on the bull, although this effect disappeared when the target was viewed through an orthoptic sight. With the ordinary open sights there was also a tendency to blur. With the lower illuminations the bull was decidedly clearer.

There seems little doubt that personal impression plays an important part in this matter. I have found that people with short sight are more apt to experience blurring, due to excessive brightness, than those with normal vision. Slight inflammation or watering of the eyes has a similar effect.

No doubt the high standard of eyesight required in the Army renders the effect of defective illumination less marked among recruits than among members of volunteer corps, whose vision is in general less perfect. But it is evident that even for people having normal vision there is a limit to the desirable brightness of targets. I believe it is generally considered impracticable to sight on the flame of a

* As the term foot-candles frequently occurs in this discussion a definition of this term is given on p. 281.

Mr. J. S. Dow (*communicated*):—
I have had the privilege of visiting a

candle amid dark surroundings, and a marksman who attempts the feat of shooting off the wick has to rely on a pot shot. Now the brightness of a candle-flame is about the same as that of a white target receiving 500—1,000 ft.-candles, so that it is not difficult to believe that many people would find a brightness of 50 ft.-candles excessive. It is common knowledge that a fine wire cannot be seen against an unduly bright background.

Another important point to recognise is that this glare-effect is intensified by the dark surroundings. A marksman finds no difficulty in aiming at a target on an open range, receiving full sunlight and illuminated with an intensity of perhaps 2,000 or even 5,000 ft.-candles. But he

For these reasons it appears reasonable to suggest that the contrast between the brightness of the target and its background should not be severe, and that complete darkness at the firing point should be avoided. Mr. Trotter has mentioned that he shot better on an outdoor range than on one illuminated in the usual artificial manner (see p.254). When visiting this outdoor range with Mr. Trotter I measured the contrast between the white target and the dark boards behind it and found the ratio to be about 8 : 1, while the contrast between the target and the grass foreground would be very much less. On the other hand, the illumination of the walls in the average artificially lighted range is usually too low



Reproduced from Part 2 of the Musketry Regulations (Plate 51) by permission of the Controller of H.M. Stationery Office.

Miniature Cartridge Range, R.E. Depot, Chatham.

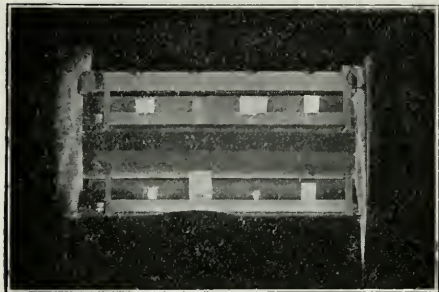
would certainly find such a brightness intolerable in a dark room. There seems little doubt that the expansion of the pupil aperture in a dark room diminishes the acuteness of vision of many people whose sight is imperfect; so far as his short experience of the matter goes, this is true for my own eye. I am also conscious of the "after-image" effect which was described by Dr. Ettles, and occurs when the gaze is shifted from the target to the adjacent darkness.

to measure, and the contrast may exceed 1,000 : 1.

During a recent conversation with an officer who has trained a considerable number of recruits on two similar ranges, lighted respectively by natural and artificial means, I was informed that better results were usually obtained by the men who shot in daylight. On the other hand, a private in Kitchener's Army told me that of the men in his battalion a considerable proportion of those who

had attained proficiency on an artificially lighted miniature range failed completely when promoted to work on an outdoor service range, and had to return to the miniature range for further training. In a few cases men had even to be discharged because they never attained proficiency on the outdoor range. Does not this suggest that the peculiar conditions on some artificially lighted ranges are not a good preparation for work under service

of H.M. Stationery Office for this picture to be reproduced. The conditions shown in this photograph, taken evidently by daylight, surely approach much nearer to practical conditions than would be the case were the artificial light derived from the suspended lamps to be employed.



Range at the Guildhall (mentioned by Mr. G. Herbert).



Range at the Polytechnic, Regent Street.

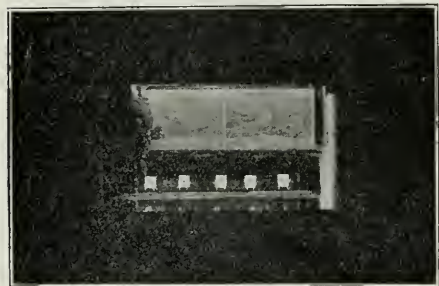
conditions? The question of the comparative effects by natural and artificial light well deserves study, and it would be interesting to collect opinions from a number of officers who have had practical experience of the subject.

In the illustration on p. 279 I am reproducing, at Mr. Trotter's suggestion, a

The chief reason assigned for darkening the firing point is that inconvenient reflections from the foresight occur when artificial illumination is used. But such reflections are merely images of exposed bright sources. If concealed lighting, and a moderate degree of illumination were used they might be avoided, and there would be the additional advantage that the instructor could see the attitudes of those firing and correct any incipient faults.

Mr. A. P. TROTTER (*communicated*), summing up the discussion, writes:—It has been my privilege to stimulate and perhaps to provoke a discussion rather than to attempt to teach or to dogmatize, for it has been clear that almost every speaker has had a longer experience than mine.

The wide range of interests covered by our Society has enabled it to investigate a matter which seems to be remote from its professed objects. Members have reduced to definite measurements the



Range of the City of London National Guard, Blackfriars Bridge.

view of a miniature range which occurs in Part 2 of the Musketry Regulations (Plate 51). Permission has been kindly granted to the Society by the Controller

intensity and the distribution of illumination and the surface brightness, and have given detailed description of many miniature ranges and have examined the physiological conditions which affect the question.

Mr. Blok's proposal to use a surface brightness of about 5 foot-candles for the background and 10 for the target seems to be a good one. It would be sufficient to show the top of the backsight and would, perhaps, allow attention to be directed to the target better than a white background. In reply to his question about the experimental range which Mr. Brazil had kindly arranged several members have reported that they had found considerable improvement, although the illumination of the targets happened to be about half that of an ordinary range.

Mr. Freak refers to the light background of this range. This might be applied to any range by the use of white-wash, or colour wash as recommended by Mr. Bernard Pickard. The intermediate screens are intended to flood the eye with diffused light, for the purpose of contracting the pupil, as in daylight. Naked lights would be intolerable.

Mr. J. G. Clark's painstaking records show that great latitude is permissible in the illumination. In comparing open and closed ranges he says that proficiency at the one means proficiency at the other. No doubt proficiency at the closed range is generally but not always associated with proficiency in the open. I am quite sure that there are many who, like myself, find that they can make good work on a daylight range and very bad work at a dark one where the targets only are illuminated.

Dr. Ettles confirms the observations which I made with some diffidence, about the multiple images and about the special difficulties of men who have reached middle age. His proposal to show up hits on the "bull" as bright points is a very good one. It would be encouraging to a beginner, but it may be difficult to carry out.

Mr. Brazil referred to some matters connected with aiming. The "U" sight is undoubtedly an improvement on the "V" for deliberate firing, but for rapid it needs a little practice, as it is so small that it is not easy to see. He emphasizes the important matter that rifle shooting is to be learned by successive steps, and that these should be made as easy as possible for the beginner. Whatever objections there may be to orthoptic sights either for passing qualifying tests or for warfare, Mr. Brazil appears to be justified in recommending them for the beginner, who would thus gain confidence even if he felt, as I did, that practice with such sights would be lost time because they would not be allowed afterwards. Mr. Brazil does well to point out the uselessness of firing for practice without "spotting" or coaching.

Mr. A. Schamasch supports Mr. Brazil in recommending that the recruit should have troubles removed as much as possible from the start, but he does not extend this to the use of aperture sights or to the blackening of sights.

Other writers and speakers have taken part in a discussion which, though directly interesting to a small proportion of the members of the Society, must be gratifying to them all as a useful contribution to the struggle in which we are all engaged.

THE "FOOT-CANDLE."

(See footnote on p. 279.)

For the benefit of those who are not familiar with illumination measurements it may be well to state the meaning of the above term, which frequently occurs in the discussion.

A foot-candle is the illumination

received from a source of one candle-power falling perpendicularly on a surface at a distance of one foot from the source.

Surface brightness is also expressed in foot-candles, and is generally assumed to be the brightness of white cardboard receiving an illumination of one foot-candle.

A SUMMARY OF VIEWS ON THE LIGHTING OF RIFLE RANGES.

THE answers to many points in the *List of Queries* (referred to on p. 250) are at present incomplete and in many instances only tentative suggestions can be made. The following is intended to represent a summary of the views expressed in the discussion on the subject and to indicate points on which further information is desired.

(1) A miniature range is intended mainly for beginners, and to enable learners to acquire the elements of the art of holding a rifle, aiming and firing. Naturally, experience of many matters, such as judging distance, the effect of wind and varying atmospheric conditions, &c., can only be obtained afterwards in the open.

(2) Conditions should therefore be made as simple and easy as possible, and if the use of light mainly to illuminate the target simplifies the conditions, this course should be followed. However, after a certain amount of practice, learners might make use of pictorial targets, and possibly arrangements might be made to enable the conditions to be altered in other respects to approach more nearly to practical conditions.

(3) Some consider that firing on artificially lighted ranges, as at present arranged, conduces to skill in a specialised and artificial type of shooting; but it is also suggested that any habits so acquired are quickly corrected in the open. Further information is needed on this point.

(4) It appears that the eye can adapt itself to widely varying intensities of illumination, but the power of adaptation is probably less among older men. Some people, undoubtedly, experience a loss of definition and an impression of glare if the illumination exceeds a certain value. An illumination less than 5 foot-candles seems to be exceptionally low and probably insufficient. For a black and white target an artificial illumination of 15—20 foot-candles is considered comfortable; 50 foot-candles is apt to be dazzling. For pictorial targets 20—30 foot-candles is suggested.

(5) Experience differs as to the effect of a dark background to the target. To a young man with good vision, the difference so caused may not be great. Some people, however, find that severe contrast prejudices ease of aiming. A moderate contrast appears preferable, but the point requires further elucidation.

(6) Many speakers express the view that complete darkness in the range, and light concentrated only on the target, are not desirable. Methods of obtaining a moderate, well-diffused general illumination are recommended, and it is suggested that indirect lighting should be used, especially at the firing point.

(7) Targets in which the contrast between bull's-eye and card is less than that obtained by printing black on white may be used by those who have first gained experience with the ordinary variety. In the case of pictorial targets attention should be paid to the *colour*, as well as the intensity of the light.

(8) No unscreened bright lights should be visible from the firing point. There is not sufficient evidence to indicate whether better results are habitually obtained by daylight than by artificial light. But this appears to be the personal experience of many men who are advancing in years, and may also be true for some young men.

(9) See (2) and (6). Some hold the view that a nearer approach to natural lighting conditions is desirable and would make shooting easier. The methods to be adopted in securing these conditions require further study.

(10) Some illumination at the firing point is desirable in order to enable moving targets to be manipulated, and assist the instructor to watch the actions of men firing. If indirect lighting is used it should be possible to avoid inconvenient reflection from the sights. Suggestions would be welcomed for improved means of observing and recording results. The lights should preferably all be under the control of the instructor.

[It is proposed to appoint a Joint Committee to deal with the unsettled points revealed in the above summary, with a view to preparing a Specification for the Lighting of Rifle Ranges.—ED.]

PROFESSOR D. A. LOUIS.

IN the death of Professor D. A. Louis, on March 25th, the country has lost a man of wide scientific attainments and exceptional personality.

Professor Louis was almost equally well known in the scientific world and in journalistic circles. In the earlier part of his career he studied chemistry, physics and metallurgy at the Royal School of Mines, and he was subsequently engaged on agricultural research in connection with some important experiments by Sir John Lawes.



Later he accepted an appointment in Colorado, where he gained practical experience of mining, and in subsequent years he practised as a consulting mining engineer, and paid visits to most of the mining districts in Europe and the United States. In 1893 he became an assistant examiner to the Board of Education, and in 1900 he was Professor of Mining at the Yorkshire College, Leeds.

Professor Louis also devoted attention to petroleum, visiting the oilfields in many parts of the world, and taking an important part in the Third International Petroleum Congress at Bucharest in 1907. His wide international knowledge and experience proved of great value in connection with several congresses of recent years. In 1910 he was Hon. Secretary of the Metallurgical Section of the Seventh International Congress of Applied Chemistry. For many years he was Foreign Representative of the International Association of Journalists.

As a writer he possessed a remarkable power of grasping the essentials of a subject at short notice and his wide scientific knowledge was never at fault. He was the author of many papers before scientific societies and articles in encyclopædias and various technical journals. His style was incisive and he was generally recognised as an excellent reviewer. Yet, though he did not hesitate to condemn faults, no one was readier to recognise and appreciate true merit.

Professor Louis took an interest in the work of many institutions. He was also a member of the Illuminating Engineering Society. On more than one occasion he proved a good friend to the Illuminating Engineering movement by his support in the Press, and up to the very end he expressed a great interest in its progress.

The writer, in common with all who knew Professor Louis, will long cherish a remembrance of his genial and kindly disposition, and the touch of whimsical humour which made him so delightful a companion. His loss will be deeply felt by a wide circle of friends.

LEON GASTER.

THE ARTIFICIAL LIGHTING OF MOVING PICTURE STUDIOS.

BY WILLIAM A. D. EVANS.

As the time has now arrived when increased output of moving pictures is demanded from the manufacturers in this country, and as this is almost entirely a question of artificial lighting, some facts as to what has been done in the United States, where the production of pictures in large quantities has been for some time a highly organised business, may be welcome. This business now ranks as the fifth industry of the country. It includes the production and manufacture of the films, the exhibition of them and the accessories necessary for the exhibition.

Everywhere, the motion picture has been elevated from the position of being only a "side-show" and is more than competing with the ordinary theatres. It might almost be said that the moving picture was a daily necessity.

The majority of "picture fiends" have naturally become interested in the different actors and the various producing companies; and by the introduction of feature plays and serial films, each of the various companies is endeavouring to build up an individual following.

Twelve years ago there were probably only five studios for the production of films where there are now more than one hundred. The large amount of money which has been made in this industry and the possibilities of future profits has drawn capital for the formation of new enterprises from various sources, and with the creation of so many new companies, competition has become keen, and the cost of producing films has become an important factor.

In the making of a picture the costs may roughly be divided into:—Cost of raw film; interest and depreciation charges on buildings and equipment; salaries of actors, directors and mechanics; cost of developing and printing and the cost of lighting.

Just what relation these various costs bear to one another is doubtful, but it has been stated that in the United States completed films cost to make anywhere from two shillings (\$5.00) to a pound (\$5.00) a foot, the average being approximately eight shillings (\$2.00) per foot.

The raw film itself costs approximately 1½d. per foot for the negative and 1½d. per foot for the positive. Naturally the highest cost is for labour, and in this respect the moving picture industry does not materially differ from many other

manufacturing processes. Any way in which labour costs can be kept down and labour utilised to its fullest capacity, is bound to decrease the cost of the film and increase the profits of the manufacturer.

One item which tends to help utilise labour to its fullest extent is proper light. The first maxim in the moving picture studio is that "no picture can be made without proper light and plenty of it." Sufficient light has to be provided, whether it be daylight or artificial light, to take clear pictures in approximately 1/50 of a second. They must be taken with detail, as they are projected to a magnification of about 150 diameters on the screen, and the public is becoming more and more critical regarding proper definition of the subject projected.

The stop used is generally about F 4.5, with a 2-inch lens, and if there is not an abundance of light, the picture will not be satisfactory when the camera is working at the required speed.

The first indoor studios depended on daylight for their lighting by the use of overhead glass skylights; later, studios were constructed not only with overhead lighting, but with the sides also of glass. Even under these conditions, on rainy and cloudy days, or about three o'clock in the afternoon during the autumn and winter months, the daylight available was insufficient to produce good pictures.

At about this period the Cooper-Hewitt lamp had been developed, and its high actinic values were justly appreciated by the few studio managers who were then in the business, and an installation of these lamps was made in 1905 at the Biograph Company's original studio on the 14th Street, New York City. From this installation has come the practical development of the Cooper-Hewitt lamps for the moving picture stage.

Few people who see the films on the screen appreciate what has to be done to take even the simplest scene, after a scenario has been accepted by a company and turned over to the producer who is the successor of the stage manager. The actors must be selected for the various parts and given instructions; scenery must be found for the setting, or, if necessary, new flats, etc., painted, and erected on the stage. The necessary "props" must be got together, and after rehearsing the scene time and again until the producer is satisfied, he calls for "Lights" and then for "Camera," and the picture is taken. Fifty or sixty feet of film, which requires about one minute to photograph, may have taken two or three hours to rehearse. All scenes

occurring in the same set are generally taken one after another irrespective of how they occur in the scenario, and after developing, the sections of the films are joined together in their proper places.

In setting a scene, conditions are different from those in a theatre, inasmuch as a scene is not played over a rectangular stage, but on one in which the stage is built like a triangle, so that the scene will occur within the angle of the camera lens. Inasmuch as the height of each picture on the film is about $\frac{3}{4}$ inch and the width one inch, the angle for height varies from that for the width. Figures

On most stages the front line is approximately 8 to 10 feet wide, and has the camera 15 feet in front and the lens at a height of about 4 to $4\frac{1}{2}$ feet from the floor. The average depth of stages for small sets is anywhere from 10 to about 15 feet back of the front line. A large stage may extend upwards of 32 feet up, back from the front line.

Not only is it essential that the action should be confined within certain limits, but the lighting must be so arranged as to light the stage properly, and yet keep the lamps in such a position that the camera will not shoot into them.

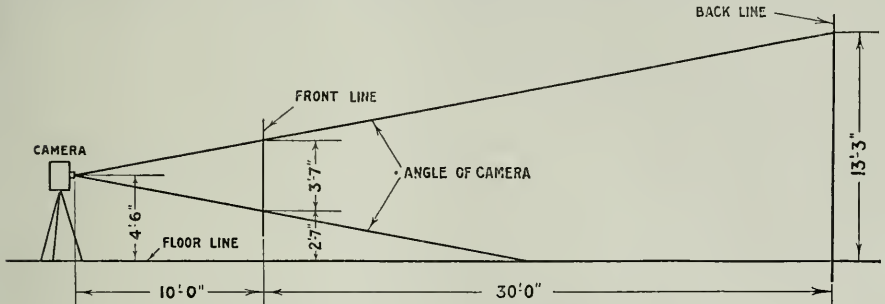


FIG. 1—Elevation of moving picture stage showing camera lines.

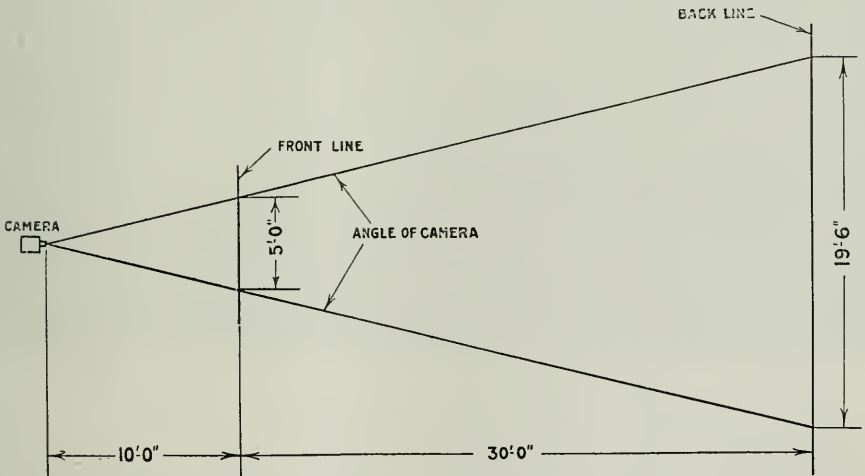


FIG. 2.—Plan of moving picture stage showing camera lines.

1 and 2 show the approximate lines along which a play is staged. All action must be confined within these lines, for if an actor oversteps a line, he is out of position, and moreover, if he should walk too far forward his legs and sometimes his head will be chopped off by the angle of the camera lens. It is thus seen that when working "close up" the action has to be carried on in a comparatively small space.

The importance of light is emphasised by the statement that no matter how good the scenario may be, or how well it may be worked up, the result of the efforts of the producer and actors will not register clearly and accurately on the film if the action is not properly lighted.

The most efficient way to light a stage either wholly dependent on artificial light or using it in conjunction with daylight is by means of Cooper-Hewitt lamps

arranged in banks, say, eight tubes. Each of these banks throws a mass of light upon the scene similar to that from a fair size window or skylight.

The Cooper-Hewitt lamp is particularly desirable for this class of work on account of the great actinic power of the light ; for equal illumination, it being about the same as daylight. Also the fact that the light comes from a long tube in place of being concentrated in a small point, ensures thorough diffusion of the light and gives a lighting effect similar to daylight. The light blends with daylight, and where used in a daylight studio can gradually be added as the daylight decreases.

Lamps are frequently arranged in skylights for hanging from the ceiling to provide top light, and floor stands are added to take care of the side lighting and reinforce the lighting at special points to obtain the best effects. By properly arranging the lights around the sides of the stage and overhead, modelling effects can be produced which do away with flat pictures which are apt to result from improper lighting.

As an instance of the manner of lighting a studio for large stage work, we may take a stage about 32 ft. deep. In a typical installation of this type there are 208 tubes, 136 for overhead lighting and 32 for high side lighting, with 48 mounted in

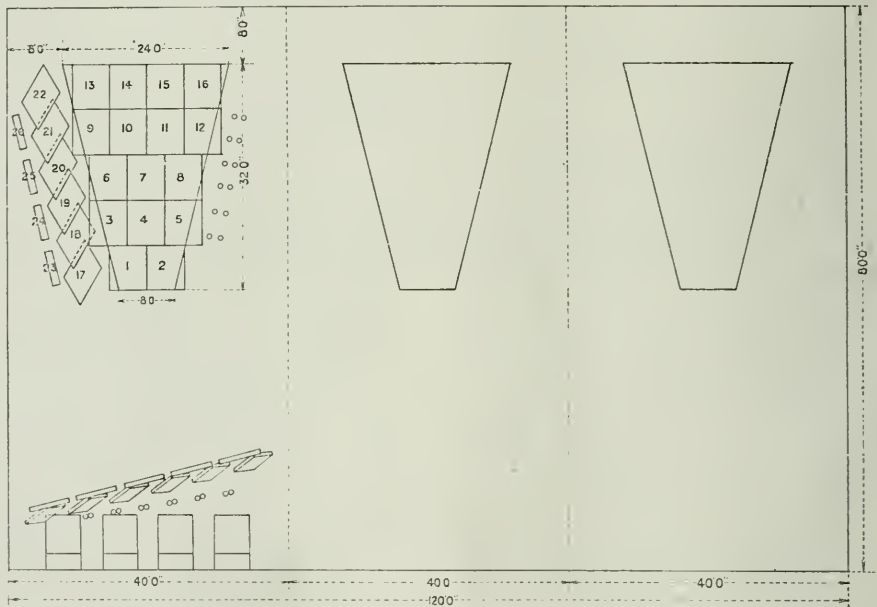


FIG. 3.—Arrangement of lamps for illumination of typical stage : two adjacent unoccupied stages are also shown.

○ indicates quartz mercury lamp. □ C.H. floor stand lamp.
 □ C.H. skylight frame.

Even with two or three hundred lamps on a stage there is very little glare, and no harmful effects are produced on the eyes of the actors. Furthermore, even with this large amount of light, the temperature of the stage is only slightly raised above the surrounding atmosphere. This is a most important point to be considered in taking pictures, and especially in fairly long scenes, as the fatigue produced by an excess of light will prevent the players from putting forth their best efforts.

floor stands for moving about to throw the light from one side and towards the front.

The overhead lamps are arranged in the following manner :—Eight tubes in two banks are hung at approximately 8 ft. over the front line, at an angle of about 30 degrees inclined toward the stage ; back of these lamps are hung three banks of eight lamps, each at the same angle, and this idea is carried out so that at the back line there are four banks, at about 18 ft. above the stage, this fan-shaped method being essential to cover the stage.

On one side are four hanging banks which are inclined 45 degrees, throwing the light in on the stage. No lamps are placed opposite to these, for the reason that if the illumination was equalised the picture would photograph flat. The floor-stands are placed at various positions to get light in on the stage to light up spots where the top and side lighting do not reach and to produce artistic modelling.

The overhead lamps in this studio are

A large studio may consist of as many as four stages completely lighted with Cooper-Hewitt lamps. Each stage is completely lighted, and no trolley system is needed for changing the position of the lamps. In other words, four different sets can be photographed at the same time, or while one or two sets are being taken, others can be set up, which eliminates lost motion, and there is no waiting for light at any time.



FIG. 4.—Showing massed mercury vapour lamps for illuminating scene in cinema studio.

as suspended from a trolley system which permits the lamps to be moved from one end of the studio to the other, and cover in this manner three different stages. By this method scenes can be set up on two stages while pictures are being taken on the third, and no time is lost between the taking of the scenes.

In addition to Cooper-Hewitt lamps a studio should have four or five large arc lamps, which can be used in conjunction with the tube lamps for spot lighting effects. Moreover, arc lamps are used for fireplace lighting, table lamps, and other special lighting effects.

The main advantage of lighting a moving picture stage with Cooper-Hewitt lamps, is primarily, the fact that pictures can be taken at the proper speed and at any time, day or night, with lighting effects that are equal to daylight. Moreover, the camera-man never has to make any change whatsoever in the aperture of his lens during the taking of a scene, as the quality and quantity of light is always the same. Passing clouds and the many changes in daylight values do not occur in an artificially-lighted studio, and pictures taken under Cooper-Hewitt light always show the same degree of clearness

and detail. Sometimes, in taking outdoor pictures, the same scenes have to be taken over and over again, due to the fact that the light was not just right. "Retakes" are not necessary in a studio with artificial lighting properly installed.

The high actinic value of the Cooper-Hewitt lamp is indicated in Figure 5 showing a spectrum of this light. It will be seen that there are practically four lines in the visible spectrum which stand out prominently—404, 436, 546 and 578 $\mu\mu$. Of these four lines twenty-five per cent. of the visible light is derived from 404 and 436 $\mu\mu$, which lie in the region where the ordinary film is most sensitive. It will be seen that the point of maximum sensibility is at about 404 $\mu\mu$, where the light from the Cooper-Hewitt lamp is particularly strong.

As the Cooper-Hewitt lamps used for this work require no carbons or trimming and the only cost is for replacing the tubes, which have an extremely long life, the maintenance cost is extremely low, the actual cost for maintaining tubes for this work averages from actual experience six shillings and sevenpence (\$1.35) per tube per year.

On a large stage, the cost of lighting for taking 1,000 feet of film, which would mean about two days' complete work with the lamps on for about two hours, would amount to 31s. 6d. (\$7.50) for current and 6s. 3d. (\$1.50) for maintenance, or a total of 38s. (\$9.00) for 1,000 feet, whereas the entire cost of the film may have run from £200 to £800 pounds, depending on the subject. In other words, the best lighting can be obtained on the average for less than one-half of one per cent. of the entire

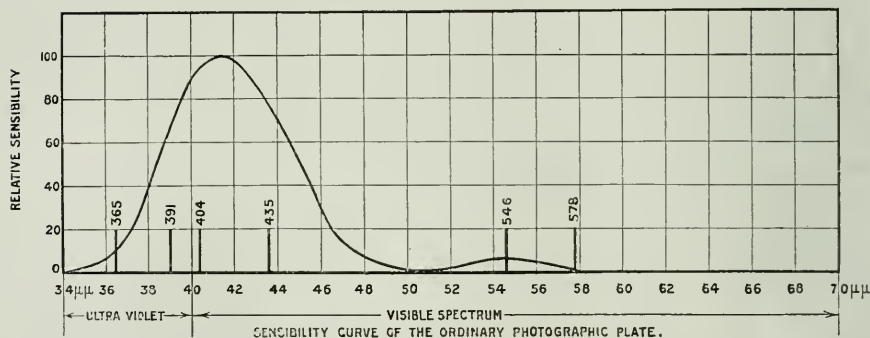


FIG. 5.—Sensibility curve of ordinary photographic plate and spectrum of mercury lamp (shown by numbered lines).

In figuring on the total illumination for a stage, it will be found that proper lighting can be produced by Cooper-Hewitt lamps with an expenditure of current of about 100 watts per square foot of floor space, that is, a small stage can be lighted with about 30 kilowatts, a medium size stage with 45 kilowatts, and a large stage with about 75 kilowatts. Stages lighted under these conditions will have a floor illumination averaging about 400 foot-candles. These figures serve as a useful guide for estimating purposes; it should, however, be borne in mind that, just as illumination intensities in domestic and industrial lighting vary over relatively wide limits, so they may also in the studio.

cost of the film. Considering the fact that some actors are paid £200 a week and over in salaries, or about £10 per working hour, every single minute of their time that can be saved by proper lighting is instrumental in reducing the total cost of the film.

Finally, proper photography reinforced by successful lighting will do as much to keep the "stars" before the public and build up a clientele for the film manufacturer, as will the engaging of new "stars" and the use of successful plays. The public is becoming more and more critical; and no play, no matter how good, and no "star," no matter how famous, will be able to draw unless the "Light" is good.



TOPICAL AND INDUSTRIAL SECTION.

— • • • —

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

BLANCHARD LAMPS.

(For Field Hospitals.)

We have been informed that the **Blanchard Lamps (British) Ltd.** in Faringdon Road have been very busy with Government work lately; there was recently at the premises a large consignment of lamps ready to go off to the Admiralty for a very special use which we are not allowed to particularise.

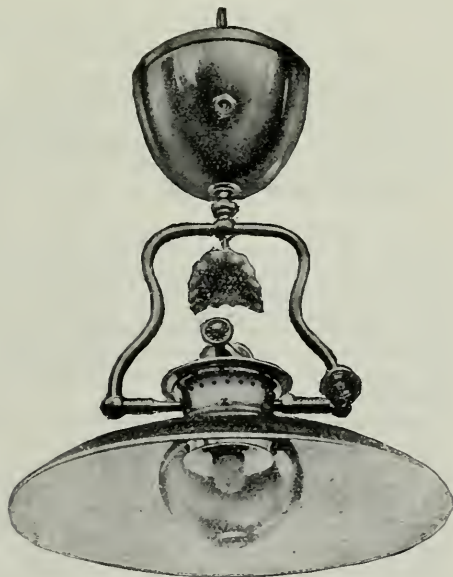
Blanchard Lamps, as readers of **THE ILLUMINATING ENGINEER** are aware, utilise incandescent mantles with paraffin or kerosene and are entirely "self-contained"; consequently they can be utilised for emergency lighting, and as portable illuminants, and are readily transferred from one place to another.

The company is well to the fore also in all movements of the moment and have designed a special lamp for use in military field or other hospitals, which we illustrate.

The particular feature of this medical lamp is its portability and the fact that while sufficiently powerful to illuminate an apartment of good size (the lamp is of 100 c.p.) it is not too heavy nor too large to be held by an assistant while an operation is in progress. We would like to draw attention to the useful reflector attached to the lamp, with a view to concentrating the light, downwards—an important point which is not always sufficiently appreciated by makers of lamps of this kind. These lamps are neatly packed in special cases containing every possible extra accessory, so that their usefulness would not be curtailed

by the thousand and one risks attendant on war service. A recent instalment was supplied to the Canadian Medical Division.

We are glad to hear that the question of the lighting of hospitals is receiving attention. Those who are engaged in supplying lamps for this purpose, which



are so vital in the alleviation of the sufferings of our soldiers, are doing indispensable work for the nation, no less than the men in the fighting line.

HARRY GUSTAV BYNG.

It is with great regret that we record the death of Mr. Harry Gustav Byng, third son of the late Mr. Gustav Byng, the founder and late Chairman of the General Electric Co., Ltd.

Mr. Byng was born in 1889. Educated at Harrow, he afterwards joined Faraday House, where he gained the Silver Medal for his year. He next entered Harvard University, passing his examinations with honours and becoming captain of the Association Football XI. After joining an exploring expedition into the less known parts of Canada, he returned to take up a responsible position with the General Electric Co., Ltd., in this country. At the outbreak of war he joined the Artists' Rifles and was subsequently gazetted 2nd lieutenant of the Second Border Regiment. He fell in battle, gallantly leading his platoon, near Festubert on May 16th. He was universally popular with his regiment and his commanding officer speaks of his death as a great loss to the battalion.

The news will be heard with keen regret by Mr. Byng's many personal friends in the electrical industry.



PERSONAL.

MR. HAYDN T. HARRISON, who is well known to readers as a member of the Council of the Illuminating Engineering Society, has been appointed Lieutenant R.N.V.R. attached to H.M.S. Vernon in order to carry out certain special work for the Admiralty.

MR. J. SCRIVENER has resigned his position of Director and Manager of Messrs. Krupka & Jacoby, Ltd., having been appointed to control the Sales Organisation of the "Z" Electric Lamp Co., Ltd., Southfields, London, S.W.

Mr. Scrivener's late co-Directors have given him, as a mark of their personal esteem, a gold watch, suitably engraved; also the Staff have presented him with a suit-case.

HALF-WATT FITTINGS.

MESSRS. A. E. PODMORE & Co. (34, Charles Street, E.C.) are well known for special work in connection with gas lighting and were the originators of a number of special forms of lanterns, lamp accessories and special shades. During a recent visit we were interested to find that the firm is also taking up the design of fittings for Half-Watt electric lamps. There is a great deal being done in this direction just now and as these lamps invariably require shading owing to their great intrinsic brilliancy, there should be a steady and increasing demand for appliances for use with them.

Established
1885.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.
Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES

Of Life Assurance, with Various Options

All Classes of Insurance Business Transacted

CHIEF OFFICES:

General Buildings, Perth, Scotland.
General Buildings, Aldwych, London.
General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, June, 1915.

	PAGE
Editorial L. GASTER.. ..	239
Illuminating Engineering Society—	
(Founded in London, 1909)	
Account of Annual Meeting, May 18th	243
Report of Council for the Session, Dec., 1914—May, 1915	245
Some Points in Connection with the Lighting of Rifle Ranges. A. P. TROTTER	251
Queries on	250
<i>Discussion—A. Blok—A. Schamasch—P. J. WalDRAM—H. Brazil—Col. Gaitskell</i>	
<i>Burr—H. Freak—W. J. Bassett—G. Herbert—Commandant of the Royal</i>	
<i>School of Musketry, Hythe—F. Bailey—S. G. Coram—T. B. Piekard—</i>	
<i>J. G. Clark—W. Ettles—Commandant of Royal Marines Depot, Deal—</i>	
<i>J. S. Dow—Frank West—A. P. Trotter (in reply)</i>	
Replies to Queries (Summary)	256
Louis, Prof. David A. (Obituary)	282
Moving Picture Studios, Artificial Lighting of. W. A. D. EVANS	282
Topical and Industrial Section :—	284
Blanchard Lamps	289
Harry G. Byng (Obituary)—Personal Notes	290
Insurance Coupon	291
Effect of Incandescent Gas on Coloured Fabrics—Lighting and Ventilation	292

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL

ACCIDENT FIRE AND LIFE

ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.

GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.

F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

THE EFFECT OF LIGHT ON COLOURED FABRICS.

SOME very interesting experiments on this subject are described in a recent report of the British Commercial Gas Association.

The object of these experiments was to investigate the effect of the light, the temperature, and the products of combustion of incandescent lamps, on coloured materials. A series of specimens of coloured fabrics were exposed to illumination of 20—40 foot-candles, the temperature being 75—80° F., and the CO₂ 9—18 parts per ten thousand. Although these effects were considerably above the normal, no appreciable deterioration in colour could be found.

A second set of colours, exactly similar to those used in the first experiment, were placed in an opaque vessel into which no light could enter but which gave free access to the vitiated air. Next, specimens were hung up in a sealed jar of fresh air, and in a third experiment the fabrics were exposed in such a manner as to receive illumination and temperature but not the products of combustion. Subsequently a fourth set of colours was suspended in a jar of perfectly fresh air, the jar being sealed to prevent the access of products of combustion, and covered with a brown paper jacket to prevent illumination of the materials. All these experiments, which were designed to test any deterioration due to the effects of illumination, temperature and products of combustion, gave rise to no appreciable change in colour. An identical set of examples was also enclosed in a sealed jar and preserved in a dark and cool place so as to serve as a standard for reference. Finally a set of specimens was exposed to full daylight, but not to artificial light.

All these experiments were continued for a period of 90 days. In the case of

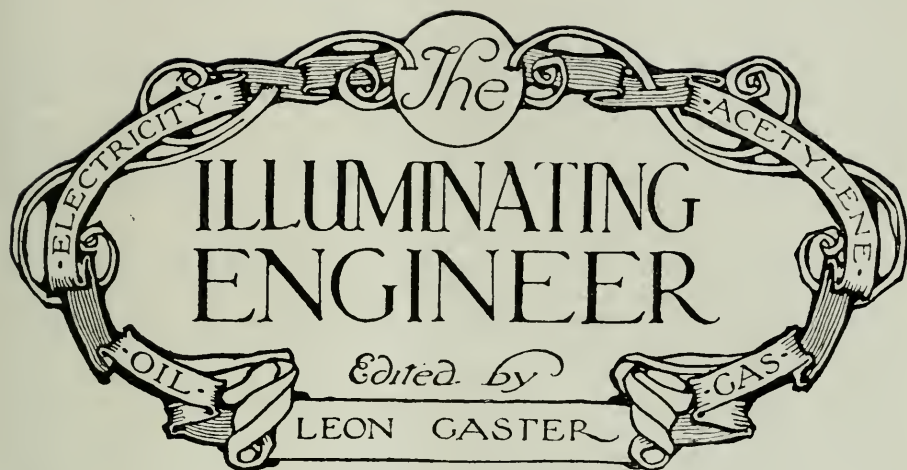
the specimens exposed to gaslight, the exposure took place continuously for 24 hours; in the case of those exposed to the daylight, the degree of illumination of course varied with the natural conditions. The essential result was that the colours exposed to gaslight altered very little, while those which were exposed to daylight changed very materially. It would appear, therefore, that daylight rather than gaslight is mainly instrumental in causing the fading of colours. Presumably this is due to the well-known fact that daylight contains a considerable percentage of ultra-violet light.

LIGHTING AND VENTILATION.

LIGHTING and ventilation are twin subjects. It is well known that the shape of modern schoolrooms is determined almost entirely on the balancing of these two factors, and in most modern installations both have to be considered. Some of the most recent gas lamps, too, have a double function. They are specially designed, not only to illuminate the room, but to promote a current which carries away the vitiated atmosphere.

A report by the Joint Committee of Ventilation Research was presented by Mr. William Harrison, the research chemist, at the annual meeting of the Institution of Gas Engineers. The report contains particulars as to the volume of air moved by various gas-consumptions and also the results of tests on a variety of types of burners. It is interesting to know that upright burners are slightly more efficient than those of the inverted type.

It was considered that the subject dealt with in this report required fuller discussion. There is no doubt that the problems of ventilation and lighting of rooms are often correlated and will have to be considered together.



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD

32, VICTORIA STREET, LONDON, S.W.

Tel. No. 5215 Victoria.

EDITORIAL.

The Organisation of Science and Invention.

During the last few weeks a series of letters by eminent men of science have appeared in *The Times* and elsewhere suggesting methods of mobilising the scientific ability and invention of the nation. The eyes of people in this country are now opened to the great possibilities of applied science, both in peace and war, and it may be hoped that fuller advantage will be taken of our resources in this respect.

We note the announcement of the formation of a Board of Inventions for the Admiralty under the Chairmanship of Lord Fisher, and we recall that Mr. Pease, in his recent review in the House of Commons, showed his appreciation of the need for better organisation of our technical resources in relation to manufacture. We believe that these views are shared by his successor, Mr. Henderson, and that the Advisory Council on Industrial

Research, when fully established in connection with his department, will do good work. Meantime, we see on all sides evidence of a willingness to help. The various scientific and technical societies throughout the country stand at the disposal of the Government. Many of the Technical Institutions are already engaged on war work; some on research, others in training men for making munitions.

The problem before us is to organise this vast mass of willing labour. The great need at the present moment is *to secure co-operation, and prevent overlapping*. The existing technical staffs of the various Government departments are naturally fully occupied with the extra routine work arising through the war. Efficient outside assistance should therefore be of service in dealing with the enormous number of novel problems that require urgent solution.

We venture to suggest a few possible methods of co-operation. Following the National Register shortly to be prepared, we should like to see a complete Register of Technical and Scientific Ability, prepared by a suitably constituted Committee acting in conjunction with the Board of Inventions and of the Ministry of Munitions. A complete list of the various technical and scientific societies able to help in any respect could easily be compiled and the Secretaries might be asked to give a summary of the lines of work undertaken by the Society, their possible applications to the war, and the kind of assistance which they would be prepared to render. Similar particulars should be obtained from the chief Scientific and Technical Institutes, so that some of them could be used for training operators in various forms of munition work, *according to a standardised and approved course of study*, the laboratories of the Colleges devoted to more advanced work being organised for research. Scholarships might be instituted and prizes offered for work on specific subjects. A list of problems requiring solution might be prepared and submitted to those Societies or Colleges capable of dealing with them. Workshops might be taken over in various parts of the country where novel appliances could be made and experimented with; officers at the Front might be invited to forward a constant stream of suggestions as to appliances and devices which might help them in their defence against attacks of the enemy.

The Secretaries or Councils of the respective scientific and technical societies could be asked to nominate some of their members, or to form a Committee to make experiments. In the case of other questions of a more debatable nature, the problem might be handed over to certain Societies for further discussion (if necessary *in camera*).

In this way a vast amount of useful information would gradually be collected, and arranged for convenient future reference at headquarters. Nor need co-operation stop here. Many of these problems would doubtless be receiving the attention of our Allies, and a constant interchange of experience between the respective countries would be beneficial in preventing overlapping of work; certain problems might be handed over to experts in the various countries who had made the subject a life-study, or were in a particularly happy position to deal with them.

Above all, our aim in future should be to stimulate and encourage invention. A problem that was half-solved, or even a problem whose solution, though very desirable, was not apparent, should not be tossed aside, but carefully studied and developed in the hope of ultimate success.

It may be said that such a comprehensive scheme would absorb the energies of a vast army of workers and would be costly. The answer is

that a large number of the workers could be recruited from those scientific men who are at present looking in vain for an opportunity to be of service ; and that the cost, though apparently high, would be well repaid in the future. The machinery built up would not be of a temporary and transient value. It would form the basis of a vast staff of expert experience, the mobilised scientific army of the country always at its service for any future emergency. Moreover, although at present our efforts must be concentrated on bringing this war to a successful conclusion, it is obvious that such a register would be of immense value in times of peace. Side by side with the purely war work there might be presently built up a corresponding organisation which could use all this mobilised ability on industrial problems of national importance ; so that when peace arrives we could use this machine for the purpose of grappling with the vast problems of restoring our industries, finding new applications for the national resources, and investigating problems of national importance. As an indication of the possibilities in this direction we have only to study the work of the British Science Guild, which has in many cases served as a useful link between the scientist, the manufacturer and the authorities, and whose experience would doubtless be of value in preparing such a Register as that suggested above.

To turn from the general to the particular, we will take the case of our own Society. Our field is the practical application of light. We have already accumulated a great deal of information regarding lamps and lighting appliances and their applications, and in the past we have discussed many problems of national importance with which we, in conjunction with other Societies, would be prepared to deal in the nation's interests.

During the past session several subjects bearing on the war, such as the development and applications of searchlights and the lighting of rifle ranges, and various problems in connection with the visibility of distant objects, have been discussed. One could call to mind many others, such as the design of optical range-finders and signalling devices, the lighting of field hospitals and the design of special illuminating appliances used in medical work and in the trenches, the lighting of camps and barracks and the provision of all sorts of lamps and portable illuminants required at headquarters—which deserve study. We know the appliances available and the sources of supply, and from the nature of our training should be fitted to recognise their limitations and suggest modifications in design for special purpose.

Similarly, in fields less directly connected with military affairs, such as the modifications in public lighting throughout the country as a measure of safety against hostile aircraft, and the regulation of the illuminating power of motor-car head-lights, our experience should be of value. When once the connection between the *want* and the *source of information* is established many other opportunities for useful service would doubtless suggest themselves.

There must be many other societies and institutions throughout the country anxious to put their services at the disposal of the State, but their members desire some assurance that their special training and experience will be utilised wisely. From this standpoint it is vital that the National Register should be supervised by men of wide experience, and that a proper classification of the scientific and technical ability available should be made.

Problems in the Lighting of Cinematograph Studios and Theatres.

There are few industries that have made such vast strides, and in so short a time, as the moving picture industry. Large sums of money have been spent in the production of films, and in the building of special theatres, and, if we may judge from reports, this is one of the few businesses in this country which have not suffered materially through the war. For one thing the stoppage of the films from the Continent has caused manufacturers in this country to redouble their efforts; also the war has led to the preparation of much special topical material of exceptional interest to the public.

In an article in our last issue the lighting of cinematograph studios was dealt with.* In this number we have a general article on some of the lighting problems met with in the manufacture and exhibition of films. There is a rich field here for the invention of the illuminating engineer. There is scope for great skill in the lighting of the theatre where the film is shown to the public, and also in the illumination of the studio where the film is prepared. There are two quite distinct problems. The lighting of studios in particular is undergoing constant changes owing to the introduction of new lamps and lighting appliances. We have already available, among the electrical illuminants, the mercury vapour lamp, various types of arc lamps, and the gas filled incandescent electric lamp, and the best methods of using them observe careful study. The conditions of lighting will differ according as one is aiming at the reproduction of the scene in a full daylight, candle light, firelight, &c. The perfection of the film depends upon the exactitude of exposure, and one would therefore suppose that the use of photometry in order to determine the amount of illumination available might be of service.

In the theatre we have again many interesting problems. It is well known that the efficiency of the projector as at present designed is extremely low. It has been estimated that of the light produced in the lantern, less than 1 per cent. is usefully employed on the screen; and of the light reflected from the screen a considerable portion never reaches the eyes of the audience, and therefore fulfils no useful purpose. It is generally agreed that the arc is the best illuminant for projector work on account of its enormous intrinsic brilliancy; yet there are other sources of light, such as the oxy-acetylene incandescent light and the half-watt lamp, which may prove to have a certain utility for the smaller types of projectors. In the choice of illuminants the avoidance of any possibility of fire would naturally be an important consideration.

Attempts have been made recently to increase the brightness of the image of the screen by receiving it on a surface composed of aluminium powder. It appears, however, that although a considerably brighter image can be obtained in this way the method has some practical disadvantages.

Finally there are other possible radical improvements such as the application of colour photography to cinematographic work. It is well known that a considerable amount of work is being done in this direction, and we have reason to believe that the prospect of success is by no means remote; some of the results already obtained are quite remarkable.

The whole subject teems with points of interest to the lighting expert, and there are few industries which offer greater rewards to the successful inventor.

LEON GASTER.

* *Illum. Eng.*, June, 1915, p. 284.

SAFEGUARDING THE EYESIGHT OF SCHOOL CHILDREN.

By M. LUCKIESH.*

THERE are stated to be 20,000,000 school children in the United States who are devoting several hours daily to study, or to other work equally trying to the eyes. According to the available statistics about 10 per cent. of the school children examined are found to have defective vision, and the percentage of defective sight rises with increasing age. Such defects constitute a great industrial handicap, and a loss in efficiency to the nation.

There is therefore every reason to study the conditions responsible for these defects and remove them. It is believed that one important contributory cause is to be found in unsatisfactory arrangements for the position of artificial light. Children reading in a poor light acquire the habit of bringing the reading matter too close to their eyes, and this process ultimately leads to near-sightedness. Glare from windows, blackboards, glazed paper or other sources of light, may also lead to eye fatigue.

Professor J. Widmark, in a paper on "Decrease of Short-Sightedness in Secondary Schools for Boys in Sweden,"† publishes some interesting statistics,† which are reproduced in Figs. 1 and 2.

Fig. 1 shows the distinct rise which occurs in the percentage of short-sightedness in the higher grades of work; the percentage seems to be highest in the classical schools, where, presumably, the eyes are more severely tried.

Fig. 2 shows the hopeful results obtained by careful attention to the conditions in the schools during the years 1895-1906.

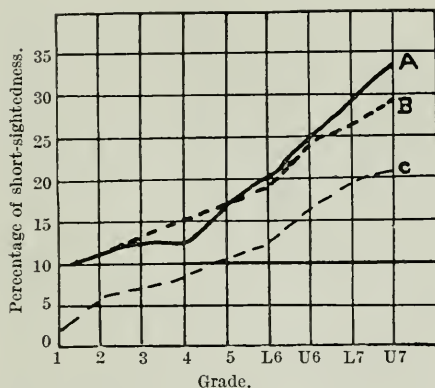


FIG. 1.—Prevalence of short-sightedness in three secondary schools in Stockholm, 1894—1903.

A—Classical school. B—Mixed school.
C—Modern school.

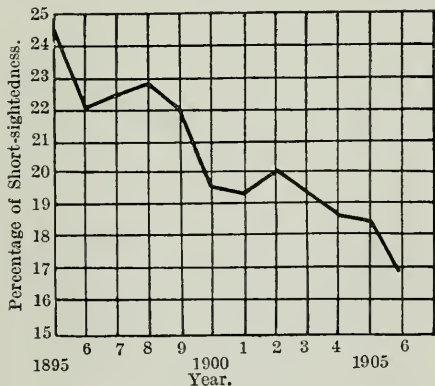


FIG. 2.—Percentage of short-sightedness in the highest class of all the State secondary schools for boys in Sweden.

* Abstract of a paper read at a meeting of the Pittsburgh section of the Illuminating Engineering Society, United States of America, Cleveland, Ohio, June 29th, 1915; Transactions of the Illuminating Engineering Society, U.S.A., Vol. 10, No. 2, page 181.

† Transactions of the fourth International Congress on School Hygiene held in Buffalo, 1913.

A steady decrease in the number of cases of short-sightedness is the result. Professor Widmark accounts for this decrease as follows :—

Among the hygienic improvements which have been affected during recent years in our schools and in all conditions relating thereto, I should be disposed to mention first the improvements in the lighting of rooms and in the printing of the books used by the pupils; and that for this reason, among others—that the influences of these changes is of effect in the homes too, the strain on the eyes when the pupils are busy with the preparation of lessons being thereby much reduced. If a comparison is made between the methods of lighting rooms now and those of ten years ago the difference is very striking, both at school and at home.

Mr. Luckiesh proceeds to quote the views of other authorities on school lighting and the need for careful specification of the illumination in the classroom. The author suggests that the most important factors, as far as lighting is concerned, are (1) intensity of illumination, (2) uniformity of illumination, (3) direction of light, (4) absence of glare. He points out the desirability of avoiding inconvenient reflection from polished surfaces; of recent years considerable decrease has been made in the use of polished surfaces. Glare from the sky or other light sources may give rise to after-images. The author gives a diagram showing how the duration of after-images is affected by the brightness of the surface and the time of exposure. It is possible that this test would be of some use in ascertaining those conditions which are inconvenient to the eyes.

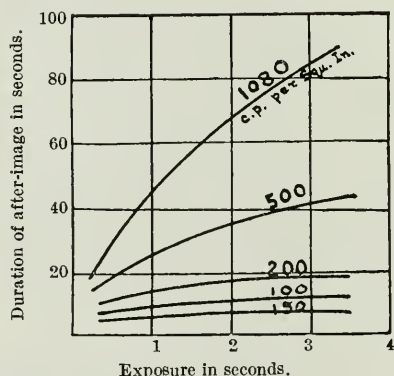


FIG. 3.—Illustrating how the duration of after-images is affected by intrinsic brilliancy and time of exposure.

Comparatively little work has yet been done showing the direct influence of glare on acuteness of vision. Mr. Luckiesh points out the need for extending such experiments for a considerable period, since the effect of glare is cumulative. It is only after a person has been working for a considerable time, that the fatigue of the eyes becomes evident. Mr. Luckiesh gives an account of some experiments showing that the glare from the blue sky gave rise to a diminution in visual acuity from 1.2 to .8 during about 15 minutes. He also found that by using special yellow-green glasses absorbing 50 per cent. of light, the diminution was much less. The following are the chief conclusions he draws from his experiments :—

(1) Glare conditions are not always apparent when the eyes are not engaged in serious work such as reading or distinguishing fine detail. However, bad lighting conditions are readily recognised when the eyes are called upon to do such work.

(2) There is a rapid falling off of visual acuity when the conditions of glare are severe.

(3) Such harmless appearing light sources as a wide expanse of sky can produce a very severe condition of glare. The intrinsic brightness is very low as compared with artificial sources, but the quantity of light is high and the image of the sky is spread over a large portion of the retina.

(4) There was an apparent recuperation of the eye during the periods that the yellow-green glasses were worn.

(5) Notwithstanding the effect of glare, when clear glasses were worn, in reducing visual acuity the values of the latter when the coloured glasses were worn remained considerably higher.

(6) This experiment emphasises the necessity of prolonging acuity readings over a considerable period if acuity is to be a criterion of the satisfactoriness of illumination conditions.

In the concluding portion of his paper Mr. Luckiesh gave a summary of the legislation of school lighting (both natural and artificial) in various States. From the study of these and also results of experiments made by a recently appointed

committee of the Illuminating Engineering Society in the United States, he makes the following chief suggestions :—

GENERAL CONSIDERATIONS.

The lighting of a school building should be referred to a competent expert before the plans for the building are drawn. The importance of doing this early is evidenced by the fact that the orientation of the building plays an important part in the design of those features which depend for their satisfactoriness upon proper lighting.

Minimum intensity of illumination, 2·5 to 3·0 foot-candles on the plane of the desk top.

Polished surfaces such as blackboards, glossy paper, polished desk tops, and glazed walls should be avoided.

Light sources (sky or artificial) should be well out of the ordinary visual field.

Glare from blackboards should be avoided. This can be done by carefully placing them, by lighting artificially, by tilting them, and by keeping their surfaces matt. They should never be placed between windows.

Excessive brightness contrasts should be avoided. A bright source should not be viewed against a dark background. The walls adjacent to a blackboard should not be too light in colour.

Surroundings such as walls and ceilings should in general be light in colour. Ceilings and frieze should be practically white (high reflecting power). Walls should be reasonably light. Colours used should be white, grey or tints of buff, cream, or olive green.

Children should be taught to safeguard their vision ; that is, how to hold their books, to assume a correct position relative to the light source, to complain of glare from blackboards, &c.

Teachers should be instructed to teach fundamentals to the children.

Good lighting should be incorporated in every course where practicable and especially in the "home-making" course.

MORE SPECIFIC RECOMMENDATIONS.

Natural lighting—Window area should be ample—that is, an appreciable percentage (say at least 20 per cent.) of the floor area.

The windows should preferably be located on one side of the room to the left of the students.

A portion of the sky should be visible from every desk top at least 5 degrees vertically.

The width of the room should not be more than twice the window height.

The windows should be equipped with approved window shades for controlling the light and excluding direct sunlight.

Prism glass should be used in extreme conditions at least.

Lighting and ventilating courts should be painted white.

Minimum illumination on desk top, 3 foot-candles.

Diversity of illumination not greater than 100 to 1.

Artificial Lighting.—Ample general lighting is recommended. Local units subject to control of pupils are condemned.

Minimum illumination on desk top, 2·5 foot-candles.

Light sources should be out of normal visual field if possible. They should be equipped with diffusing glassware to reduce their brightness and screen the source from the pupils.

Highest permissible brightness, 3 candlepower per square inch when viewed against a light background.

Blackboards should be lighted by properly screened and judiciously placed local units.

The system of lighting will depend upon many conditions. Any well-designed system is satisfactory in its proper place. There appears to be a growing tendency to use the semi-direct system, which appears more generally satisfactory for class rooms, reading rooms, &c. In the shops a direct system is advisable.

No local units should be used unless absolutely necessary.

We are glad to note that the Illuminating Engineering Society in the United States is endeavouring to co-operate with school authorities in bringing about improvements in the lighting of school-rooms. The paper is concluded by a Bibliography in which the recent data obtained by the Illuminating Engineering Society in this country are given.

DIMINISHED ILLUMINATION AND ACCIDENTS IN THE STREETS.

The Annual Report of the Coroner for the City of London and the Borough of Southwark, Dr. F. J. Waldo, makes some interesting references to the increased number of fatal accidents that have occurred in that district, during the latter months of 1914.

It is pointed out that on the whole the number of traffic deaths have decreased during the past two years. During the latter part of 1914, however, there was a significant *increase*. During 1914 these were seven deaths in the period January-March, nine from July to September, and twenty-one during October, November and December.

The Report comments on these figures as follows :—

“The only condition peculiar to the year under report is the fact that, owing to the European War now raging, the streets and bridges have, for protective purposes, been darkened during the last three months of the year. In other words, the increased traffic fatality corresponds with the darkening of the streets. In further analysing the figures in the 46 fatalities, I find of the seven accidents in the period January to March, four occurred before lighting-up time, *i.e.* from one hour after sunrise till one hour after sunset, and three after lighting-up time, *i.e.* one hour after sunset to one hour after sunrise. Of the ten accidents in the period April to June, nine occurred before lighting-up time and one after; of the nine in the period July to September five before lighting-up time and four after; while of the 12 in the period October to December, four occurred before lighting-up time and 17 after. Moreover, the evidence in those cases where darkness prevailed at the time of the accident strongly pointed in the last 17 fatalities recorded (with the exception of some three doubtful cases) to such want of light being a prominent factor in the cause of death. Four of the “dark” accidents which occurred in November and December were caused by motor omnibuses on London Bridge at a time when the lights on the bridge and vehicles were mostly extinguished or obscured in accordance with the police regulations.”

STREET ACCIDENTS.

The following table (Appendix F) gives the number of street traffic fatalities

which have occurred in the Metropolitan Police area and the City of London in each month of 1913 and 1914 respectively. This emphasizes the increase in deaths during October, November and December, 1914, the three months of enforced darkness of the streets.

Traffic fatalities in the Metropolitan area and the City of London in each month of the years 1913 and 1914.

			1913.	1914.
January	..	..	43	30
February		..	39	40
March	..	..	55	47
			—137	—117
April	..	..	43	33
May	..	..	67	43
June	..	..	53	50
			—163	—126
July	..	..	66	54
August	..	..	47	54
September	..	..	54	71
			—167	—179
October	..	..	47	92
November	..	..	55	55
December		..	56	89
			—158	—236

(Orders under the Defence of the Realm Regulations for the reduction of lighting were made on the 1st October, 31st October, and the 9th December, 1914.)

The Report continues :—

“It will be seen that the number of deaths during these three months exceeds by 78 the number for the corresponding months in 1913, and also exceeds the total of deaths in any of the three-monthly periods during the years 1913 and 1914.

“The biggest total next to that for the period October to December, 1914, is that for July to September, 1914, which total numbers 179 fatalities. This high figure may, I think, be accounted for largely by the increased consumption of intoxicating liquors indulged in, more especially by those run over and killed at the commencement of the war prior to the ‘dark’ period.

“In no one of the 46 cases has there been any evidence or suggestion that the driver of the vehicle has been drunk, or even under the influence of drink, at the time when he ran over and killed the deceased person. On the other hand the impression left on my mind is that some of the pedestrians killed, particularly in the earlier months following the outbreak of war,

were at the time of the accident under the influence of drink, and that the condition thereby induced contributed in a measure to the fatality."

The following information is given in an Appendix relating to the Home Office return for the street accidents in the Metropolitan Police District:—

"A Home Office return just issued shows that 637 fatal accidents were caused in the Metropolitan Police District in the year ending December, 1914, by vehicles in streets or public places. Of these 126 were caused by horse-drawn vehicles, 493 by mechanically-propelled vehicles, and 18 by pedal cycles. The non-fatal accidents numbered 25,239, of which 14,638 were caused by mechanically-propelled vehicles, 5,578 by pedal cycles and 5,023 by horse-drawn vehicles.

"Motor-omnibuses were responsible for 148 deaths, mechanically-propelled tramcars for 37, and other mechanically-propelled vehicles for 308. Of the non-fatal accidents 3,007 were caused by motor-omnibuses, 3,171 by mechanically-propelled tramcars, and 8,460 by other mechanically-propelled vehicles.

"There is nothing in the return to show what has been the effect on the number of street accidents of the darkening of London thoroughfares during the later three months of the year dealt with. A comparison with the previous year's return, however, shows that there has been a considerable increase in the number of accidents, those of a fatal character having grown from 579 in 1913 to 637 in 1914, and those who did not prove fatal from 18,944 to 25,239.

"In the City of London, which is separately dealt with, there were last year 19 fatal street accidents as compared with 17 in 1913, and 1,253 non-fatal as compared with 1,210 in 1913. The comparative fewness of traffic accidents in the City is, I think, attributable to the excellence of the police working directly under your Corporation, to the thorough and prompt manner in which means are taken for preventing accidents, and to the superior legal powers in connection with street traffic possessed by the City as compared with the Metropolitan Police District."

LIGHTS FOR VEHICLES.

The question of the light for vehicles also comes in for consideration:—

"As regards the important question of the need of lights on all vehicles, both behind as well as in front, and the display of such lights at an earlier hour than is the rule at present, especially during the autumn and winter months between September and March, and on foggy and dark evenings, and more especially during the darkened conditions of the streets, certain riders have been added by juries to their verdicts on traffic fatalities, and forwarded to the authorities. In one such case, a woman crossing a street in Islington, was killed by being run over, on the 23rd of October last, by a box tricycle without any light on it, at a time when the street was quite dark, notwithstanding the fact that the accident occurred 20 minutes before lighting-up time. The suggestion made and conveyed to the Home Secretary was that the lighting-up time should be altered, and that all vehicles should show a red light from sunset to sunrise in place of the present rule—from one hour after sunset to one hour before sunrise.

"In another instance the need of the new Home Office Order now partly in force, to the effect that all vehicles, including cycles and handcarts, shall show a red light, in addition to any other light, is clearly indicated, among others, by the following case. The inquest was held on the body of a man who, while pushing a hand-barrow without any light on it along Bishopsgate, at a time when the street was almost in darkness, was run into and killed by a motor omnibus. The driver of the omnibus in his evidence said he was unable, owing to the darkness of the street, to see the deceased man when he ran over him. In a recent case, when a woman was run over and killed by a motor-omnibus without lights in the Walworth Road, S.E., in the daytime during a thick fog, the jury suggested the compulsory use of lights on vehicles at such times. At present the only vehicle obliged to show lights during a fog is the tramcar."

In view of the limitation of the power of headlights during the War these cases are of special interest at the present moment.

SAFETY PRECAUTIONS IN VIEW OF THE DIMINISHED PUBLIC LIGHTING.

Shortly after the darkening of the streets the authorities found it necessary to issue a special warning against fast driving. It was pointed out that statistics showed a disquieting increase in the number of fatal accidents, and

that, owing to the darkening of lights, much greater circumspection should be exercised by drivers and pedestrians.

Later the practice of whitewashing kerbs during the period of diminished illumination was recommended with a view to making the demarcation between pavement and roadway clearer. All this involves a clear recognition of the need for a certain measure of illumination in

the interests of traffic. It furnishes a precedent for the future determination of this desirable illumination on a scientific basis, which lighting engineers have advocated for some time past.

Another result of the diminished lighting has been to induce authorities to place a limit to the brilliancy of motor headlights—also a matter which has been discussed in this Journal on several occasions previous to the war.

One point of great importance is the question of the extinction of street lights in the event of a raid by hostile aircraft. Public opinion required guidance in this matter, and we are glad to observe that an official communication has been issued to local authorities intimating that the total extinction of lights in London would be most undesirable. It is pointed out that such a course would be fraught with most serious consequences, and would possibly bring about many more casualties than would be caused by the enemy aircraft; that in the event of fires breaking out the fire brigade would not be able to reach their destinations; that the traffic actually in the streets would be dangerously impeded, and that ambulance and police movements would be hindered; and that all the elements of panic would be introduced.

The circular also states that, as a result of numerous observations made from time to time, the Admiralty are satisfied that the present system of reduced lighting is the more satisfactory condition, since an observer from the sky is quite unable to determine the quarter of London he is passing over. According to expert opinion the extinction of street lighting would rather aggravate than reduce the danger to which the public are exposed.

The public would also do well to bear in mind the advice that gas should not be turned off at the meter at night, as this practice involves a risk of subsequent fire or explosion from burners left on when the meter was shut off—a risk which would out-weigh any advantage that might accrue from the gas being turned off at the time of a raid. These recommendations are in entire agreement with the suggestions recently made in an editorial in *THE ILLUMINATING ENGINEER* (February, 1915, p. 44).

VISIBILITY PROBLEMS IN WAR.

In a lecture before the Optical Society of London Mr. J. S. Dow, on May 13th, discussed some problems in visibility arising in war. The first portion of the lecture was devoted to a summary of recent progress in the design of searchlights and signalling apparatus, in the course of which frequent reference was made to the recent meeting of the Illuminating Engineering Society devoted to this subject. The second part of the lecture dealt mainly with the effects of light on the eye, and the conditions which rendered distant objects conspicuous or the reverse.

Mr. Dow emphasised the desirability of clear conceptions of the range and candlepower of searchlights, which he suggested might, with due care, be readily tested by the aid of modern photometric apparatus and even specified. Vision, the lecturer pointed out, played a great part in modern warfare, where the combatants fought a great deal at long range. There was constant competition between the combatants, the one trying to make his arrangements inconspicuous, the other trying to devise methods by which they could more easily be seen at a distance. As an instance the lecturer mentioned some optical devices which had been suggested for the purpose respectively of making periscopes of submarines indistinguishable to the enemy, and of detecting their presence. Reference was also made to various devices, such as protective colouring or painting objects with irregular patches which masked their outlines. It was pointed out that nearly all physiological factors tended to render distant red objects easily discernible, while blue objects, on the other hand, readily faded into the background. For this and other reasons red light might be favoured for signalling purposes.

In the discussion Mr. Justus Eck mentioned the change in the design of soldier's caps for trench work, as an instance of the attempt to avoid sharp outlines; the flat top, he understood, caught the eye more easily than an irregular soft cap would do. Mr. Eck also mentioned some additional applications for searchlights, for example, as an adjunct to fire-engines. He also

described an ingenious refinement which was now fitted to the Beck searchlight, namely, the use of small selenium cell to control the position of the arc automatically and keep it always at the focus of the projector. Dr. Ettles, who was in the Chair, explained how the appearance of distant blue objects was affected by the chromatic aberration of the eye. Mr. Bryan mentioned an interesting instance of the use of blue light for illuminating the interior of guns, the idea being to secure an illumination which could not easily be seen at a distance. The significance of the "candle-power" of the searchlight, and its relation to the intrinsic brightness and superficial area of the illuminant were also discussed at some length.

THE EFFECT OF ULTRA-VIOLET LIGHT ON THE EYE.

The study of the effects of ultra violet and infra-red radiation on the eye is attended with many difficulties, and past researches on these points have led to somewhat conflicting results.

Many of these experiments relate to the formation of "cataract," i.e., a disease of the eye in which the crystalline lens becomes opaque and forms an apparent grating over the pupil. There are several facts to be accounted for, among them being (1) the tendency to cataract in old age, (2) the prevalence of this disease among workers in certain trades, notably among glass workers, (3) the prevalence of the disease in the tropics, (4) the tendency to cataract among people subject to certain diseases, such as diabetes.

On examination of these four points it would appear from (1) and (4) that cataract may have a physiological cause, such as some form of malnutrition. On the other hand (2) and (3) suggest that exposure to exceptionally strong light, glowing furnaces, etc., is a factor of consequence. The probability is that both causes are operative.

Some striking experiments which confirm this view were recently carried out in the United States by W. E. Burge.*

In order to test the effect of the visible spectrum, and of the infra-red and ultra violet rays the author exposed various solutions containing egg-white, blood-serum, aqueous and vitreous humour, and also excised pig and ox lens, to these forms of radiation. For some of these experiments an electric furnace which is particularly rich in infra-red rays, was used. For testing the effects of strong visible light a gas-filled incandescent lamp of 2,000 c.p. was focussed on the lens and solutions, exposure being made for as much as 100 hours. For the production of ultra violet rays a quartz tube mercury vapour lamp giving about 2,500 c.p. was employed.

The general result of these experiments was as follows. No appreciable coagulation, either in the solutions or the lenses, could be traced to the visible or infra-red rays. It is true that coagulation could be produced by very strong concentration of these forms and energy, but the result was shown to be due to a great rise in temperature (such as could never be approached under ordinary conditions) and not to the intrinsic effect of the radiant energy itself. When arrangements were made to prevent this rise in temperature, coagulation did not occur.

In the case of the ultra violet rays an exposure for 20 hours to the quartz tube at a distance of 5 centimetres, coagulated the solutions in the course of 20 hours. But even after 100 hours' exposure the lenses of the aqueous humour were practically unaffected, and the vitreous humour was only rendered very slightly clouded. The author considers it remarkable that, although ultra violet radiation coagulates egg-white solution, and practically every other protein and related substance, the aqueous and vitreous humours and the lenses resisted their influence. This suggests that there is some special quality in the protein substances in the eye which enable it to resist the effect of ultra violet rays. Some light is thrown on this point by the author's analysis of several thousand cataractous eyes received from the United States and India; in these cases a great increase above the normal in the amount of certain salts was found to exist. For example, while the percentage of potassium is reduced, the percentage of calcium,

* *Elect. World*, April 10th, 1915.

magnesium and sodium are greatly increased above the amounts existing in the normal lenses. In the cases of the eyes received from India, silicates were present. It seems, therefore, that the presence of these substances in the eye may diminish the power of resistance to coagulation. In order to test this point the author immersed the specimen eyes in solutions of calcium and magnesium chloride, sodium silicate, and dextrose.

In these circumstances also no appreciable coagulation could be produced by infra-red and visible rays (provided as before that the effect of rise of temperature was excluded), but on exposure to ultra violet light, the portion of the lens on the side facing the burner, became an opaque mass in 25 minutes. This occurred in the case of the lens immersed in calcium chloride, but a similar but less marked effect was met with in the presence of the other solutions.

The conclusion would appear to be that two distinct factors should be considered: (1) a modification of the protein of the lens due to malnutrition or disease, and (2) long exposure to powerful ultra violet radiation, such as exists in the sunlight of the tropics. The above experiments also explains why sufferers from diabetes are particularly subject to cataract, since it is known that this disease gives rise to an accumulation of dextrose in the system.

A NEW TYPE OF ELECTRODES FOR AN IMPROVED ARC LAMP.

In the United States, as is well known, magnetite arc lamps have been very widely used for street lighting. In an article in the *Electrical Review and Western Electrician*,* Mr. Isador Ladoff mentions the use of a new type of electrode termed "ferro-ilmenite" which is stated to give an efficiency of near 4 mean spherical candlepower per watt. This is claimed to be the highest efficiency yet reached with an electrical illuminant. The efficiency of an ideal monochromatic illuminant, yielding only light of wave length 0.545μ is given as 63.6 sph. c.p.

per watt. Taking this value as 100 the percentage of light from the energy given to the ferro-ilmenite arc is only about 6 per cent., so that we have still much to do before the ideal conditions are approached. It should, however, be recognised that a certain loss in efficiency is inevitable if we desire to have correct colour-revealing qualities, i.e., an approximate "white light." The efficiency of an ideal "white light" would not be more than 24 sph. c.p. per watt.

In the case of arcs using metallic electrodes the constitution of the cathode is the important point which settles the quality of the light. Ferro-ilmenite cathodes appear to be composed of a mixture of titanium oxide, chromium oxide, and sodium uranate. Hitherto, copper anodes have been used with this type of arc, but the author finds that anodes of graphite or iron are preferable. Still better results are obtained if anodes of this material are protected with tips of copper.

GAS LIGHTING AT THE PANAMA-PACIFIC EXHIBITION.

The *Journal of Gas Lighting* for July 6th contains several interesting photographs showing the use of high-pressure gas lamps at the Panama-Pacific Exhibition. One of these photographs shows the Netherlands Buildings on either side of which are spaced high-pressure lamps each yielding 1,160 (mean hemispherical) candles. The other photograph refers to the west end of the Palace of Fine Arts. Here the "flood-lighting" of the building and statuary is the most striking feature. High-pressure gas lighting is used throughout in this quarter and is widely employed for the colonades and boulevards in the Foreign Section.

Gas also plays an important part in the form of flambeaux for producing special ornamental effects, and in many quarters low-pressure lighting is installed for emergency purposes.

* April 10th, 1915, p. 691.

ILLUMINATION OF THE PANAMA-PACIFIC INTERNATIONAL EXHIBITION.*

BY W. D'A. RYAN.

EVERYONE in this country has been so engrossed in the war that the opening of the great Panama-Pacific Exhibition received comparatively little attention. It was anticipated that the lighting would be of a highly novel character, and in *THE ILLUMINATING ENGINEER* for October, 1914, an account was given of

It appears from this account great ingenuity has been shown. The chief respect in which the lighting differs from that in most exhibitions of the past is the absence of glare. Methods of concealed lighting have taken the place of festoons of naked incandescent lamps and an attempt has been made throughout to



FIG. 1.—Palace of Horticulture.



FIG. 2.—Tower of Jewels.

Note reflections in the water of the West Lagoon of the South Garden.

the projected arrangements. Mr. W. D'A. Ryan, under whose supervision the whole scheme was carried out, has now contributed an illustrated article on the subject in a recent issue of the *General Electric Review*, which is too interesting to be overlooked. To those in dimly-lighted London whose minds are oppressed by the war, it seems curious to read of the gorgeous spectacular lighting effects in San Francisco; but in the distant future, when we are free once more to study illumination effects of this kind, the novel methods used for the lighting of this exhibition should not be forgotten.

combine the resources of the lighting engineer and the art of the architect. The results obtained by Mr. Ryan and his staff of engineering assistants are largely due to the fact that from the very inception, they worked in co-operation with the architectural commission engaged in planning the Exhibition. "For the first time in history the lighting of an International Exhibition was completely designed and chartered before the building was erected."

In what follows we summarise Mr. Ryan's account of the lighting arrangements:—

The illumination of the Exposition marks an epoch in the science of lighting and the art of illumination. Like many

* Abstract of an article in *The General Electric Review*, June, 1915.

other features of the Exposition, the illumination is highly educational in character and emphasizes more than anything that has gone before the result of concentrated study in the best uses and application of artificial light.

Previous exposition buildings have, in the main, been used as a background on which to display lamps. The art of outlining, notably the effects obtained at the Pan-American Exposition at Buffalo, could probably not be surpassed. This method of illumination has, however, been extended to amusement parks throughout the world and is now commonplace. Its particular disadvantage is that it suppresses the architecture which becomes secondary and it is practically impossible to obtain a variety of effects, so that the Exposition from every point of view presents more or less similarity. Furthermore, the glare from so many exposed sources particularly when assembled on light coloured buildings causes eye strain. Prior to the opening night of the Exposition, there were many who maintained that the public would not be attracted except by the glare of exposed sources and great brilliancy, which was analogous to saying that the masses could be attracted only by one form of lighting. The results obtained, however, clearly disproved this theory.

The lighting effects are radical, daring and in every sense new, the fundamental features of which consist primarily of masked lighting diffused upon softly illuminated facades emphasised by strongly illuminated towers, and minarets in beautiful colour tones.

The direct source is completely screened in the main vistas and the "behind the scenes" effects are minimized to a few locations and are nowhere offensive.

Furnishing wonderful contrast to the soft illumination of the palaces, with their high lights and shadows, we have the zone, or amusement section with all the glare of the bizarre, giving the visitor an opportunity to contrast the light of the present with the illumination of the future. As we pass from the Zone with its blaze of lights, we enter a pleasing field of enticement or carnival spirit. We are first impressed with the beautiful colours of the heraldic shields on which is written the early history of the Pacific Ocean and California. Behind these banners are luminous arc lamps in clusters of two, three, five, seven and nine, ranging in height from 25 to 55 feet. We look from the semi-shadow upon beautiful vistas and the Guérin colours which fascinate in the daytime are even more

entrancing by night. The lawns and shrubbery surrounding the buildings and the trees with their wonderful shadows appear in magnificent relief against the soft background of the palaces and the "Tower of Jewels" with its 102,000 "Nova-gems," or so-called exposition jewels, standing mysteriously against the starry blue-black canopy of the night, surpassing the dreams of Aladdin.

As we enter the "Court of Abundance" from the east, with its masked shell standards strongly illuminating the cornice lines and gradually fading to twilight in the foreground, we are impressed with the feeling of mystery analogous to the prime conception of the architect's wonderful creation. Soft radiant energy is everywhere; lights and shadows abound, fire spits from the mouths of serpents into the flaming gas cauldrons and sends its flickering rays over the composite Spanish-Gothic-Oriental grandeur. Mysterious vapours rise from steam-electric cauldrons and also from the beautiful central fountain group symbolizing the Earth in formation. The cloister lanterns and the snow-crystal standards give a warm amber glow to the whole court and the organ tower is carried in the same tone by coloured searchlight rays.

Passing through the "Venetian Court," we enter the "Court of the Universe," where the illumination reaches a climax in dignity, thoroughly in keeping with the grandeur of the court, where an area of nearly half a million square feet is illuminated by two fountains, rising 95 feet above the level of the sunken gardens, one symbolising the rising sun and the other the setting sun.

The shaft and ball surmounting each fountain is glazed in heavy opal glass which is coated on the outside in imitation of travertine stone so that by day they do not in any sense suggest the idea of being light sources. Mazda lamps installed in these two columns give a combined initial mean spherical candle-power of approximately 500,000 and yet the intrinsic brilliancy is so low that the fountains are free from disagreeable glare and the great colonnades are bathed in a soft radiance. For relief lighting three Mazda lamps are placed in specially designed cup reflectors located in the central flute to the rear of each column. This brings out the Pompeian red walls and the cerulean blue ceilings with their golden stars and at the same time the sources are so thoroughly concealed that their location cannot be detected from any point in the court.

The perimeter of the "Sunken Garden" is marked by balustrade standards of

unique design consisting of Atlantes supporting urns in which are placed Mazda lamps of relatively low candle-power. The function of these lights is purely decorative.

The great arches are carried by concealed lamps, red on one side and pale yellow on the other, thereby preserving the curvature and the relief of the surface decorations. The balustrade of this court, 70 feet above the sunken garden, is surmounted by 90 seraphic figures with jeweled heads. These are cross lighted by 180 Mazda searchlights, the demarcation of the beams being blended out by the light from the

Palace of Fine Arts bathed in triple moonlight and casting reflections in the lagoon impossible to describe. The effect is produced by searchlights on the roofs of the Palaces of Food Products and Education supplemented by concealed lighting in the rear cornice soffits of the colonnade.

You have only passed through the central, east and west axis of the Exposition. There are many more marvels to be seen. If you wish to study the art of illumination you could visit the Exposition every evening throughout the year and still find detail studies of interest. For instance, did you ever see artificial



FIG. 3.—Rotunda and Colonnade of the Palace of Fine Arts.

fountains of the rising and the setting sun.

Passing through the Venetian Court to the west, we enter the "Court of the Four Seasons," classically grand. We are now in a field of illumination in perfect harmony with the surroundings, suggesting peace and quiet. The high current luminous arcs mounted in pairs on 25 ft. standards masked by Greek banners are wonderfully pleasing in this setting. The white light on the columns causes them to stand out in semi-silhouette against the warmly illuminated niches with their cascades of falling water, and the placid central pool reflects in marvellous beauty scenes of enchantment.

Having reviewed in order illuminations mysterious, grand and peaceful, we emerge from the West Court upon lighting classical and sublime, the magnificent

illumination in competition with daylight? On certain occasions the projectors flood-light the towers before the sun goes down. If you are fortunate enough to be present, take up a position in the northwest section of the "Court of the Universe" and watch the marvellous effect of the "Tower of Jewels" as the daylight vanishes and the artificial illumination rises above the deepening shadows of the night. The prismatic colours of the jewels intensify and the tower itself becomes a vision of beauty never to be forgotten.

The South Garden may very properly be called the fairy-land of the Exposition at night. When the lights are first turned on, the five great towers are bathed in ruby tones and they appear with the iridescence of red hot metal.

This gradually fades to delicate rose as the flood-light from the arc projectors converts the exterior of the towers into soft Italian marble. The combination of the projected arc light (white) and the concealed Mazda light (ruby) produces shadows of a wonderful quality. Each flag along the parapet walls has its individual projector which converts it into a veritable sheet of flame.

As a primary line of colour the heraldic shields and cartouche lamp standards produce a wonderful effect against the travertine walls bathed in soft radiance from the luminous arcs which also bring out the colour of the flowers and lawns and create pleasing shadows in the palms and other tropical foliage. This is supported by a secondary effect in the decorative Mazda standards along the "Avenue of Palms" and throughout the garden. A finishing touch is added by the effect of life within created by the warm orange light emanating from all the Exposition windows supported by red light in the towers, minarets and pylon lanterns.

To the west we have the enormous glass dome of the Palace of Horticulture converted into an astronomical sphere with its revolving spots, rings and comets appearing and disappearing above and below the horizon and changing colours as they swing through their orbits. The action is not mechanical, but astronomical.

To the east, we have the "Festival Hall" flood-lighted by luminous arcs and accentuated by orange and rose lights from the corner pavilions, windows, and lantern surmounting the dome, all reflected in the adjacent lagoon and possessing a distinctive charm which will long remain in the memory.

Purely spectacular effects have been confined to the scintillator at the entrance of the yacht harbour. This consists of 48 36 in. projectors having a combined projected candle-power of over 2,600,000,000. This battery is manned by a detachment of United States Marines.

A modern express locomotive with 81 in. drivers is used to furnish steam for the various fireless fireworks effects known as "Fairy Feathers," "Sun-Burst," "Chromatic Wheels," "Plumes of Paradise," "Devil's Fan," &c. The locomotive is arranged so that the wheels can be driven at a speed of 50 or 60 miles per hour under brake, thereby producing great volumes of steam and smoke, which, when illuminated with various colours, produces a wonderful spectacle.

The aurora borealis created by the searchlights reaches from the Golden Gate

to Sausalito and extends for miles in every direction. The production of "Scotch Plaids" in the sky and the "Birth of Colour," the weird "Ghost Dance" "Fighting Serpents," the "Spook's Parade" and many other effects are fascinating.

Additional features consist of ground mines, salvos of shells producing "Flags of All Nations," grotesque figures and artificial clouds for the purpose of creating midnight sunsets.

Over 300 scintillator effects have been worked out and this feature of the illumination is subject to wide variation. Atmospheric conditions have a great influence upon the general lighting effects; for instance, on still nights the reflections in the lagoons reach a climax, particularly the Palace of Fine Arts as viewed from Administration Avenue; the facades of the Education and Food Products Palaces as seen in the waters through the colonnade of the Palace of Fine Arts; the Palaces of Horticulture and Festival Hall from their respective lagoons in the South Garden; the colonnades and the Nova-gems on the heads of the seraphic figures, and the "Tower of Jewels" as reflected in the water mirror located in the North Arm of the "Court of the Universe."

On windy nights the flags and jewels are at their best. On foggy nights wonderful beam effects are produced over the Exposition impossible at other times. When the wind is blowing over the land the scintillator display is different from nights when the wind is blowing across the Bay. A further variety is introduced in the action of the smoke and steam on calm nights.

On the evening of St. Patrick's Day all the searchlights were screened with green; not only the towers but every flag in the Exposition took on a new aspect.

Orange in various shades was the prevailing colour for the evening of Orange Day and on the ninth anniversary of the burning of San Francisco the Exposition was bathed in red, with a strikingly realistic demonstration of the burning of the "Tower of Jewels."

High pressure gas lighting plays an important part in street lighting in the foreign and state sections; low pressure gas for emergency purposes, and gas flambeaux for special effects.

The accompanying illustrations suggest some idea of the illumination, but the addition of colour is absolutely necessary to convey anything approaching a correct impression of the night pictures of the Exposition.

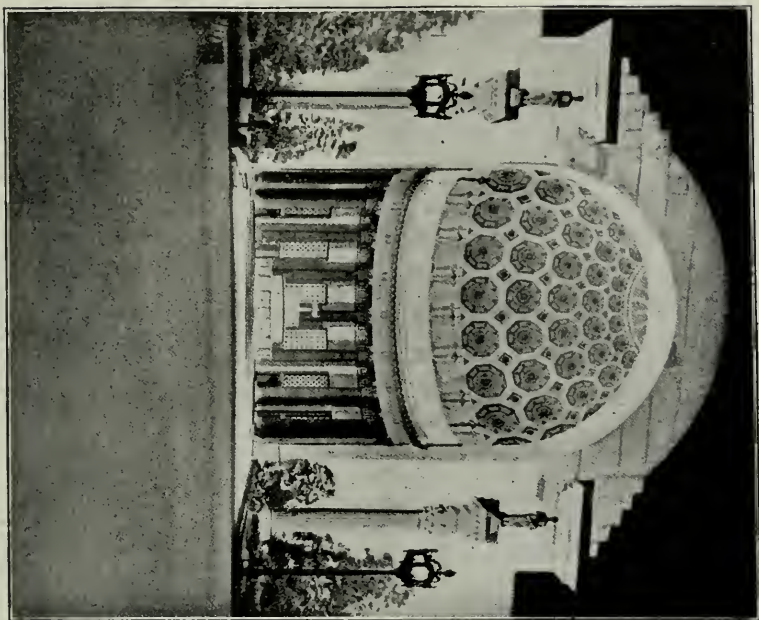


FIG. 4.—West entrance to Food Products Palace, showing 35 ft. 3-light luminous arc cartouche standards.

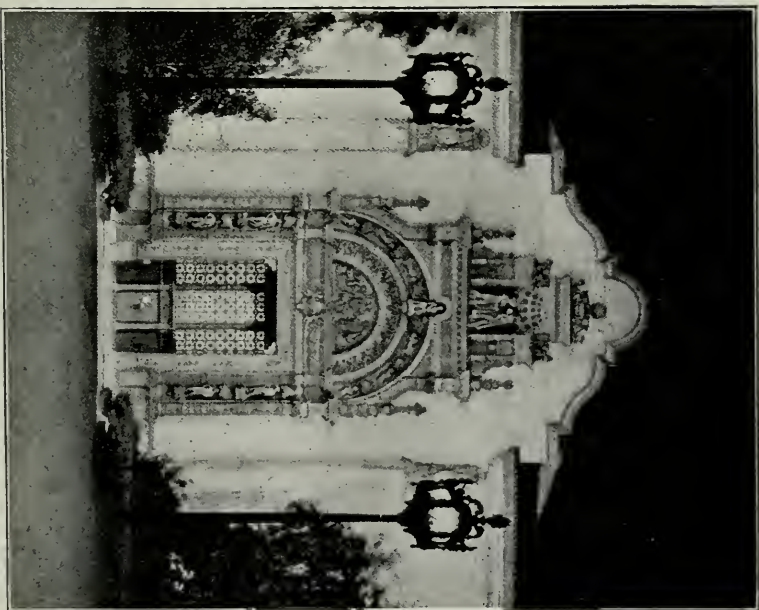


FIG. 5.—Entrance to Varied Industries Building, lighted by 3-light luminous arc cartouche standards.

SOME NOTES ON THE USE OF LIGHT IN CINEMATOGRAPH WORK.

By AN ENGINEERING CORRESPONDENT.

There are many interesting applications of light in connection with cinematograph work, which deserve the attention of the illuminating engineer. Broadly, there are three distinct sections of the subject to be investigated: (a) The lighting of the picture palaces in which the film is displayed; (b) the design of the projecting apparatus and the study of the illuminants used therewith; (c) the lighting arrangements used in the studio where the photographs are taken.

LIGHTING OF THEATRES.

Some notes on the lighting of picture palaces appeared in *THE ILLUMINATING ENGINEER* about two years ago.* In the higher class of cinematograph theatres the lighting is now carried out with considerable skill, and is usually well adapted to the purpose in view. There are, however, still some points to be investigated, and, from a decorative standpoint, there are great possibilities. The fundamental point in such lighting is that all unduly bright lights liable to cause glare must be rigorously avoided. As a rule the audience sit in almost complete darkness; in these circumstances even an unscreened candle flame used by the performer at the piano has been found inconvenient. One reason for this is that in a weak illumination the peripheral region of the retina is highly sensitive to light; consequently glare from bright objects seen out of the "tail of the eye" is accentuated. From the standpoint of safety it is generally agreed that a small amount of subdued light is desirable in the auditorium, and there are reasons for thinking that this is also advantageous with a view to comfort of vision. An excessive contrast between the brightly illuminated screen and the relatively dark surroundings in the auditorium is, in some measure, inconvenient to the eye. It is recognised that the abrupt "shock" produced by suddenly turning off all the lights in the

auditorium is trying to the eyes, and the use of "dimmers" is now recommended in order that the illumination may gradually be diminished. But it is also possible that a permanent very strong contrast between the picture and the surroundings may be productive of strain, and that the audience would see more conveniently if the ratio between the brightness of the screen and the brightness of the surroundings was kept within a certain limit. This limit remains to be determined. Experience suggests that the illumination in the auditorium should be of the order of 0.2 to 0.5 foot-candles; at a rough guess one would estimate that in these circumstances the brightness of the surroundings on a level with the audience would be about one-twentieth to one-fiftieth of that of the screen; but if this illumination were produced by concentrating reflectors the brightness of the upper part of the auditorium would be considerably darker, so that the average value of the ratio might be greater than the figure quoted. In his well-known recommendations for the avoidance of glare Prof. L. Weber suggested that a contrast of more than 100:1 gave rise to glare, and this seems in fair agreement with the conclusions so far reached in the lighting of rifle ranges.

Indirect and semi-indirect methods of lighting seem particularly well adapted to the lighting of auditoriums; clusters of lamps mounted on the ceiling are also useful for the purpose of producing the desired general illumination. Chandeliers situated anywhere near the direct range of vision should not be used.

ILLUMINANTS AND PROJECTOR APPARATUS.

The illuminants suitable for projector work are, generally speaking, those which are also available for searchlights.* Intrinsic brilliancy is the most important factor. Where electricity is available the

* Vol. 6, 1913, p. 476.

* See *Illum. Eng.*, Feb. 1915.

arc light, the intrinsic brilliancy of which (estimated at 120—140 c.p. per sq. millimeter) considerably exceeds that of other sources, is naturally preferred. In other cases limelight and the oxy-acetylene incandescent system are used. For small model projectors incandescent tungsten lamps have possibilities, and future developments in this field may lead to their being more widely employed. Half-watt lamps have been designed for projector work, and the latest bunched spiralised filaments represent a great advance on the lamps of a few years ago. We shall probably see a further improvement both in the intrinsic brilliancy of the filament and in its construction. From the optical standpoint a filament, however ingeniously arranged, is naturally inferior to an approximately spherical and continuous incandescent area such as exists in the electric arc or limelight. On the other hand the heat developed is much less, and this may enable the source to be brought nearer the condensing lens. The fact that small units are readily available is a convenience for work in small rooms. One drawback there would seem to be—the danger of an incandescent lamp filament unexpectedly giving way during a performance. If, however, a well-designed arrangement were embodied for immediately switching into circuit a spare lamp kept ready for the purpose, the interruption might escape notice.

No information is available as to the application of cooled electrodes in projectors on the principle used in the Beck searchlight. The added complexity of the system would be a drawback, and the first cost inevitably much greater. But the fact of being able to obtain four times the light for the same current, as is reputed, might mean that the initial cost would be more than compensated by the saving in running expenses.

When it is recalled that projectors used for cinematograph work frequently consume 50 ampères at 65 volts, it will be understood that the cost of electricity may be a considerable item. When only a high electric pressure, say 200 or 250 volts, is available, it is wasteful to lose all the excess P.D. on a resistance, and a motor-generator converting the pressure

to 65—70 volts is well worth the first cost of installation, which will be covered by the saving in running cost during the first few months.

It is also well known that an alternating current is much less satisfactory than direct current for projector work, owing to the fact that the tips of both carbons shape alike and no well-defined incandescent crater is formed. Moreover, greater skill is usually required in order to get a steady light from an alternating arc. As a rule, therefore, it is better to install an auto-converter and transform from alternating to direct current.

The design of the optical system of the projector hardly falls within the scope of this journal, except in so far as it affects the efficiency of the projector. The system consists essentially of two parts, (a) the condensing lens and (b) the projecting or image-forming lenses. Limitations in lens manufacture, and the necessity of avoiding any danger of the condenser being cracked by the heat, both restrict the luminous efficiency of the system. Few people realise how small is the percentage of the light produced in the arc which is actually usefully employed on the screen. The brightness of the latter is much less than is generally supposed. In a number of theatres recently tested by the author it did not exceed 1—2 foot-candles. Now, in the case of a screen ten feet square, the flux of light received by it in these circumstances would be 100—200 lumens. Therefore, if *all* the light produced in the arc were usefully employed only $\frac{100}{4\pi} - \frac{200}{4\pi}$, *i.e.*, approx.

8—16 spherical candle-power, would be needed! In practice several thousand candle-power might be required to produce this illumination, so that the “useful efficiency” of the projector could be set down as less than 1%.

This example serves to illustrate the great theoretical scope for improvement in the design of the optical system, but it seems difficult to secure any substantial improvement without departing entirely from the principles which have been tried and tested for so many years.

But this by no means exhausts the elements of inefficiency. Even when the picture has been formed on the screen a

great deal of light is scattered from its illuminated surface in useless directions. In general, a cinematograph theatre is long and narrow so that a maximum number of people can be present looking directly towards the screen. The rays of light that are scattered in oblique directions, where there are no spectators, is therefore wasted. Attempts have been made to improve the efficiency of the screen by using screens of powdered aluminium which reflect a much larger percentage of the light towards the audience and yet diffuse the light sufficiently to produce a continuous image. Such screens have been scientifically grooved and rippled to bring the light back to the audience, and it is said that in this way an image bright enough to be seen in broad daylight can be obtained. Yet there are various practical difficulties, and such screens have not been widely adopted in this country.

There remains to be mentioned yet another possible line of research, in which a number of experiments are being made—the production of a stereoscopic image. If to the excellent definition now attainable in the cinematograph image one could add the effect of depth and distance, a great step forward would have been taken; but this, too, is still in the experimental stage.

THE LIGHTING AND EQUIPMENT OF STUDIOS.

In the third section of cinematograph work, taking photographs of subjects for exhibitions, artificial light plays a great part. It would probably be agreed that good daylight conditions are the most satisfactory of all for this purpose; on the other hand, daylight is a very variable quantity, particularly in northern latitudes. Considerable fluctuations in illumination during the taking of a film would naturally inconvenience the producer. If these variations are undetected by the eye, the film may be under- or over-exposed. It is well known that considerable changes in the strength of daylight are apt to escape notice owing to the eye's great power of adaptation to varied conditions. It seems reasonable to suppose, therefore, that photometry might be a useful check. If the illumination were observed through an instrument of the

lumeter class while the film is in progress, warning could be given at any moment if the light were diminished or increased by more than a certain amount. The advantage of artificial light lies in the fact that it is more under control than daylight, and more constant in strength. An artificially lighted studio can be used irrespective of the climatic conditions in summer and winter, and films can be prepared even though the light out of doors may be insufficient for photography.

There appear to be, generally speaking, two distinct classes of studios, those (usually fairly large in area) lighted on a permanent scheme with the sources of light in fixed positions, and those (in which smaller scenes are staged) lighted by portable units. In some cases the overhead units are arranged on a travelling rack so that they can be transferred bodily to a series of studios under the same roof. An article in our last issue gave some information on this point, dealing, however, mainly with the use of mercury vapour lamps.*

In any case the arrangements of the light and shade require considerable care. If the brightness of the sources is too concentrated, harsh shadows would be produced, the contrasts would be excessive, and some detail in the film would be missing. On the other hand, if the light is too completely diffused, there will be a lack of shadow and the film will be "flat." It is necessary to strike a mean between these conditions, and, as a rule, the lighting consists of a combination of general diffused illumination supplemented by light coming from some special direction. The shadow conditions which are aimed at will naturally depend on the nature of the scene. For example, they will vary according as the scene is supposed to take place in a room lighted artificially by chandeliers, candles, etc., or in full open daylight. In addition, a special arrangements will be made for firelight scenes, etc. The time of exposure for each picture in a cinematographic film is of the order of one-sixty-fourth of a second, and it will, therefore, be understood that a very high illumination is necessary. Curiously enough, no data

* *Illum. Eng.*, June, 1915, p. 284.

seem to have yet been published regarding the illumination provided; but if arc lamps or mercury vapour lamps are used, one may assume that it is of the same order as would be required by daylight and would amount to hundreds of foot-candles. This figure, however, naturally depends to some extent on the actinic qualities of the light used. As was mentioned in the article in our last issue (*loc. cit.*) mercury vapour lamps are widely used for the purpose, partly on account of the high actinic value of the light, and partly because of the soft and diffused character of the illumination produced by the long tubes. When arc lamps, or gas-filled incandescent lamps are used, a translucent screen is usually fixed in front of the source so as to soften the shadows. It is stated that the half-watt lamp is about one-third to one-fourth as actinic as daylight and the mercury vapour lamp. It is interesting to observe that of the four lines which are prominent in the visible spectrum of the mercury lamp the line $546\ \mu\mu$ is located at the point of maximum sensibility of the eye; while the line $404\ \mu\mu$ is lighted approximately by the point of maximum sensibility of the photographic plate.

A recent article by Mr. V. A. Clarke in the *Electrical World*,* compares the efficiency of various forms of arc lamps for cinematograph work. From the standpoint of minimum cost to secure a given photographic effect the 200-volt direct current enclosed arc taking 150 volts across the arc and consuming 3 amperes was found to be the most economical. The comparative efficiency of ordinary and flame arcs, both for direct and alternative current, depends to some extent on the special circumstances. The following data, taken from an interesting paper read by Mr. Luckiesh before the Illuminating Engineering Society in the United States,† give an idea as to the lighting requirements of various studios:—

- I. Set about 16 ft. by 30 ft. (4.9 by 9.1 m.).
124 mercury-vapour tubes, d.c., 112 volts,
3.5 amperes.

Energy used, about 50 kw.
Lamps arranged in banks of 8 each.
Placed 48 overhead inclined at about
30 deg. from horizontal and 12 ft.
(3.65 m.) from floor.

64 on one side in banks two tiers high.

12 at front 7 ft. (2.1 m.) above floor.

Actors worked to within 10 ft. (3 m.) from front lights.

- II. Set about 16 ft. by 25 ft. (4.9 by 7.6 m.).
24 carbon arcs, a.c., 220 volts, 14 amperes.
Energy used, approximately 50 kw.
Placed 16 overhead and 8 in front about
8 ft. (2.4 m.) from floor.
Actors worked to within 10 ft. (3 m.) from front lights.

- III. Set about 14 ft. by 20 ft. (4.3 by 6 m.).
18 carbon arcs, d.c., 110 volts, 20 amperes.
2 30-ampere carbon arcs in series for flood light through a window.
Energy used, approximately 43 kw.
Placed 12 in front and 6 on side near front
from 4 to 7 ft. (1.2 to 2.1 m.) from floor.
Actors worked to within 5 ft. (1.5 m.) of front lights.

- IV. Set about 15 ft. by 15 ft. (4.5 m.).
12 carbon arcs, d.c., 110 volts, 20 amperes.
Energy consumed, approximately 27 kw.
Placed in front overhead in two rows
about 8 ft. and 9 ft. (2.4 and 2.7 m.)
from floor.
Actors worked to within 7 ft. (2.1 m.) of front line of lamps.

- V. Set about 12 ft. by 24 ft. (3.6 by 7.3 m.).
48 mercury arcs, d.c., 110 volts, 3.5 amperes.
2 carbon arcs, d.c., 110 volts, 28 amperes.
2 carbon arcs, d.c., 110 volts, 30 amperes.
3 quartz mercury arcs, d.c., 110 volts,
3.5 amperes.

The 3 quartz mercury arcs and 2 carbon arcs were in front and the 48 mercury arcs were distributed on one side with the exception of two banks of 8 each which were near the front on the other side. None overhead. The 2 30-ampere carbon arcs were on the side near the front and about 10 ft. (3 m.) from the floor. These gave a marked effect in the picture. This appeared to be an exceptionally intelligent attempt to obtain good lighting effects.

Energy consumed, about 33 kw.
Actors worked to within 7 ft. (2.1 m.) of front line of lamps.

- VI. Set about 10 ft. by 10 ft. (3 m.).
11 1,000-watt gas-filled tungsten lamps,
110 volts.
Placed in front corners about 8 ft. (2.4 m.)
from floor. More lamps on one side
than the other.

Energy consumed, 11 kw.
Light well controlled by angle reflectors.
Actors worked to within 5 ft. (1.5 m.) of front line connecting the lamps.

- VII. Set about 10 ft. by 15 ft. (3 by 4.5 m.).
16 1,000-watt special blue-bulb, gas-filled tungsten lamps, 110 volts.
Placed 8 in front, 6 on side near front,
2 overhead.

* Nov. 14, 1914, p. 956.

† *Trans. Ill. Eng. Soc. (U.S.A.)*, Vol. X.
No. 2, 1915, p. 181.

Energy consumed, 16 kw.

Actors worked to within 7 ft. (2.1 m.) of front.

There has been much speculation as to the utility of the recently introduced half-watt (gas-filled) incandescent lamp for cinematograph and portrait work. They appear to be of value for enlargement and printing purposes, but their presumably lower actinic value would make them less efficient for cinematograph work than arc lamps or mercury vapour lamps. According to Mr. Luckiesh the actinic value of such lamps for a given illumination is only one-third to one-fourth that of daylight or the mercury vapour lamp. Moreover, their intrinsic brilliancy makes it necessary for a translucent screen to be used.

But it is expected that such lamps will form a useful adjunct for accentuating the light in certain directions; for this purpose the small volume of the luminous area, which enables focussing reflectors of various types to be used and the light to be more completely controlled, is claimed as an actual advantage.

It is also suggested that even for cinematograph work as now conducted the approximately white character of the light used by these lamps is advantageous.

COMBINED CENTRAL AND BRACKET LIGHTING IN A DRAWING ROOM

At one time there was much discussion regarding the comparative merits of central and bracket lighting in a small drawing room. When the indirect and semi-indirect lighting systems became common, the former method received a distinct stimulus.

Many people, however, consider that a combination consisting of a central semi-indirect unit, supplemented by well-shaded bracket lights, is the best arrangement. The illustration shows a good modern example of this method. The general effect is soft and the bracket lights just suffice to remove any impression of "flatness" which might otherwise exist.

Although cinema pictures operate in black and white the distortion of colour caused by mercury vapour lamps alone may, in certain scenes, be undesirable. And if hopes are realised of ultimately producing applying colour photography to cinematograph work, the use of an illuminant giving an approximately white light would become essential. Mr. Luckiesh has also found the gas-filled lamp serviceable in connection with ordinary indoor portrait work, and has made one interesting modification. In order to secure a short exposure the light has to be very powerful and the glare from the lamp would be somewhat trying to the subject, even if screened in the usual way. Mr. Luckiesh has therefore introduced a glass screen which has the effect of diminishing the luminous value of the light to 30 per cent., but leaves its photographic value practically unaffected. The screen has also the quality of making the colour of the light an apparent match with daylight; it could, therefore, be used to supplement daylight if desirable. Finally, there is the advantage that the actinic power, corresponding with a given luminous effect, is the same as for daylight when this screen is used. In fact, it produces what may be called "approximate photographic daylight."



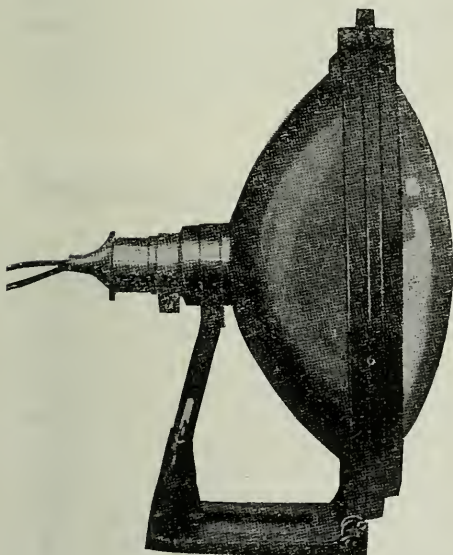
SHORT NOTES

ON

ILLUMINATING ENGINEERING.

ILLUMINATION OF SIGNS AND BUILDING EXTERIORS BY PROJECTORS.

IN the *Electrical Review and Western Electrician*,* an account is given of a new form of "flood-light" type of lighting unit which is being used in the United States for illuminating the outsides of buildings, signs, and other objects.



This projector consists of a highly polished aluminium parabolic projector 16 in. in diameter and mounted in an iron frame. The front is covered with curved heat-resisting glass. A 500 watt focus type gas-filled lamp is mounted

with the filament at the focus of the reflector. In this way approximately 400,000 apparent candle-power is obtained. By putting the lamp slightly out of focus a spread of 18° is obtained, the apparent candle-power in this case being 150,000.

By a slight adjustment the unit can therefore be employed to illuminate either very distant objects or those which are comparatively near at hand. With the projector located 100 feet away and the beam concentrated to 6° a minimum spread of about 10 feet, with an average foot-candle intensity of 30 foot-candles, is obtained. By increasing the dispersion to 18° the maximum spread is about 30 foot and the average intensity of illumination 5 foot-candles.

Some illustrations are given of buildings illuminated in this way. They appear very conspicuous against a dark background. For average conditions 2 foot-candles are usually sufficient. A special use of the projectors is for illuminating signs which cannot be conveniently lighted by lamps on the spot.

ARTIFICIAL DIGESTION BY ULTRA-VIOLET RAYS.

ACCORDING to a report published in the daily Press, Professor Daniel Bertholet claims to have reproduced artificially the processes of digestion by the action of ultra-violet rays from a mercury vapour lamp on food substances contained in a quartz vessel.

The processes were produced without the aid of ferments, which play so great a part in the natural processes.

* May 29th, 1915.

PHOTOMETRIC TESTS OF STREET LAMPS IN A LAWSUIT IN PHILADELPHIA:

ACCORDING to the *Electrical World* a lawsuit recently took place in Philadelphia with reference to the candle-power of about 18,000 gasolene mantle street lamps in outlying districts. The contract specification stated that lamps were to be tested photometrically as to the actual street illuminating power and that the minimum value should be 60 candles. It was therefore added that the illuminating power should be tested by horizontal measurements at the city's photometric stations or elsewhere.

A reduction from the rate of 29 dollars per lamp per year was to be made for whatever percentage the lamps in each district averaged below 60 candles. But when the tests came to be made it proved impracticable to remove the burner to a laboratory to test. They had therefore to be tested on the spot. Two plans were tried; one of these was to attach a photometer to the lamp-post and reflect the horizontal candle-power into the photometer by means of mirrors. A second method was to mount a laboratory photometer and bar with an automobile truck, which was carefully housed in with tarpaulins. On the basis of these tests the city deducted an amount of 53,000 dollars, proportional to the shortage in candle-power recorded.

The Company brought suit to recover this amount.

In the course of the evidence a great array of experts, including Dr. L. Bell, Mr. C. F. Lacombe, Mr. C. O. Bond, Mr. J. R. Cravath and others gave evidence. Eventually the case was decided in the favour of the Company.

COLOUR AND HEAT.

AN issue of the *Times* last year contained nearly a column devoted to the physiological effects of various kinds of light. Sunburn is said to be caused by the ultra violet rays of sunlight. But the visible rays have also an influence on us. The red rays are believed to be stimulating, while the blue have a sedative and even a depressing effect. Workers in rooms with red glass windows have been known to become excited, and a similar effect has been noted in small-pox patients submitted to red ray treatment. It is pointed out that these psychological effects have a distinct influence on the selection of colour. Red acts as a tonic, "is a whip to jaded nerves," blue light is soothing, and baths of light of this kind have been recommended in cases of over-excitement and neuralgia, &c.

Ultra violet rays in excess are bad to the skin, and sunburn following constant exposure is not necessarily an indication of health. On the other hand, such rays have a powerful germicidal action, and rooms into which the sun never shines are rightly suspected as being unhealthy.

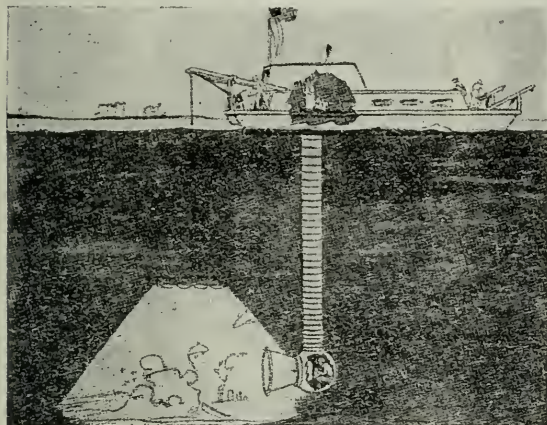
COLOURED LIGHT AND THE MODERN COMPOSER.

SCRIABINE, whose methods as a composer were extremely novel, proposed the combination of colour effects with his music.

He suggested altering the colour of the light in the auditorium according to the nature of the music, and was said to contemplate the evolution of a new form of colour music based on the projection on a screen of various constantly altering coloured designs. Some experiments in this direction were carried out by Mr. Wallace Rimington many years ago; the idea being that by projecting coloured patterns of varying form and intensity on a screen it should be possible to form subtle colour harmonies which appeal to the eye in much the same way as an intricate musical piece appeals to the ear.

SUBMARINE PHOTOGRAPHY BY AID OF A QUARTZ MERCURY LAMP.

THE illustration shows an interesting development of submarine photography which was recently described in the *Electrical Review and Western Electrician*.* The area to be photographed is illumin-



ated by a battery of nine 2400 candle power quartz mercury vapour lamps.

* May 29th, 1915.

“MATCHING THE SNOW.”

It has often been asserted that the German greenish-grey uniforms are specially adapted to render the troops difficult to distinguish against an ordinary background of trees and grass. On the other hand, the fact that colours in nature are constantly changing makes it difficult to secure these conditions permanently; one would imagine, for example, that the khaki of the British troops might be preferable in autumn when the prevailing tints are brown and yellow. Naturally the same holds good in the desert and in sandy plains.

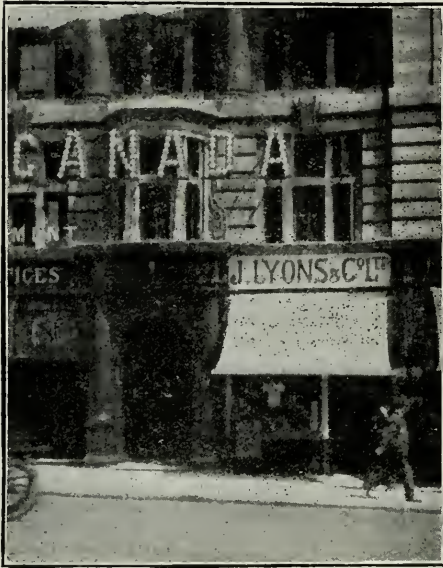
The Germans are said to have made preparations for the winter campaign in Poland by ordering coats of the lightest

The photographer is lowered to the requisite distance by means of a telescopic tube, which expands into a chamber about 5 feet in diameter. One side of this chamber is provided with a glass observation window, from which the pictures are taken. The chamber will contain two men, and a constant supply of fresh air is admitted from above.

It is stated that the American inventors of this apparatus (Mr. C. Williamson and his two sons, of Norfolk, Va.), claim to be able to take moving pictures at a distance of 100 feet. This appears to be a remarkable result, and leads one to wonder whether the illumination of distant objects under water by a searchlight beam is such an impossible process as is generally supposed. At the present time, when submarine warfare has made such great progress, the question is certainly an interesting one.

possible shade to match the snow. Presumably when the spring came they reverted to the ordinary colours. This chameleon-like change of tint according to environment is surely a new thing in warfare.

Other instances of this mimicry of Nature are provided by the operations in the Dardanelles, in British East Africa, and on the Italian frontier. It is stated that the Alpini on reaching the snow line put on white garments over their tunics. In British East Africa some of the horses are striped like zebras, which renders them difficult to distinguish at a distance. In the Dardanelles the Turks concealed amidst the foliage are said to have adopted the practice of painting their hands and faces green!



A DAYLIGHT SIGN.

This type of sign has been described in *THE ILLUMINATING ENGINEER* in connection with signals for aircraft.* Each letter is made up of silvered hemispheres which catch the light and appear very brilliant objects in the sunshine.

The sign "Canada" is a prominent object in Whitehall (London).

* Vol. V., 1912, p. 395.



SIGNS AT RAILWAY TERMINI.

At main railway stations in London flame are lamps have for some years been used to illuminate signs indicating the approach to the various tube-connections.

The arc is hung within a square composed of translucent glass and the illumination is strong enough to render the sign quite a conspicuous object.

ILLUMINATING ENGINEERING SOCIETY, U.S.A.

CHANGES IN THE CONSTITUTION ADOPTED.

At the recent election of the Illuminating Engineering Society in the United States, Dr. C. P. Steinmetz was elected President, Mr. L. B. Marks, Treasurer, and Mr. A. S. Miller, General Secretary.

We observe that the proposals to

amend the Constitution of the Society have been adopted by a vote of more than six to one. It will be recalled that these proposals involved the division of members into two classes, known respectively as "members" and "associate members" and paying respectively ten dollars and five dollars per annum. No doubt this step will considerably increase the revenue of the Society.

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

An Introduction to the Study of Colour Vision. By J. Herbert Parsons, D.Sc., F.R.S. (Cambridge University Press, 1915; 308 pages, 75 illustrations.)

THE study of photometry and illumination has brought home to many of us the complexity of the human eye, especially in regard to the perception of colour. It is impossible to enter deeply into these subjects without acquiring some acquaintance with physiological optics. But the more one learns the more one recognises the spreading vastness of this field of knowledge and the difficulty of keeping abreast of the recent advances in research. The old landmarks are changing and the subject is in a constant state of flux. Moreover, some of the most important of these researches appear in abstruse transactions of foreign societies such as are not readily accessible to the ordinary reader.

An up-to-date treatise placing this information at the disposal of British readers is therefore most welcome. Mr. Parsons reveals a deep knowledge of the subject, and has succeeded in dealing with the complex problems of Colour Vision in a concise and lucid manner.

The book is divided into three parts dealing respectively with "The Chief Facts of Normal Colour Vision," "The Chief Facts of Colour Blindness," and "The Chief Theories of Colour Vision." In the first section the author makes frequent reference to the work of Abney, König, von Kries, McDougall, and many other well-known authorities. After a brief descriptive analysis of the physical, anatomical, and psychological bases of vision, the author discusses the luminosity of the spectrum, the effects of adaptation of the eye to darkness and brightness, and the effect of receiving the luminous

image on different regions of the retina. Subsequently there is an account of such phenomena as recurrent vision, flicker, the production of after-images, and the effects of fatigue—all matters which have an indirect bearing on photometry and illumination. Mr. Parsons, as one would expect from a Vice-President of the Illuminating Engineering Society, is familiar with recent work on flicker photometry and refers to some of the experiments carried out by photometrical experts in this country and in the United States. Very interesting is the account of the sense of colour possessed by various birds and reptiles, and the experiments that have been made on dogs and other animals. The section is completed by two chapters on the colour vision of primitive races and the colour vision of the child.

In Part 2 the author discusses the highly complicated problems of colour blindness and again gives an excellent series of references.

Part 3, devoted to theories of colour, contains matter which will be new to many readers. After dealing with the well-known Young-Helmholtz and Hering theories, the author gives a brief summary of the more modern developments due to Donders, McDougall, Edridge-Green, and others—developments which are only now becoming known among physicists.

The reader cannot fail to be struck by the extreme difficulty of framing a comprehensive variety of colour vision and the complexity of the effects to be accounted for.

The book contains evidence of the vast amount of work that has been done on this subject, and should be of interest to many workers in other fields, besides those directly concerned with the study of colour vision.

The Bye-Products of Coal Gas Manufacture. By K. R. Lange. Translated from the German by Chas. Salter. (Scott Greenwood and Son, 1915; 155 pages, 13 illustrations.)

At the present moment, when the public have been forcibly reminded of the development of the coal tar industry abroad, this little volume should be welcome. The first portion of the book is devoted to an account of the composition of coal and the purification of coal gas. Subsequently the author goes on to explain the nature of gas tar and gas liquor and to describe their treatment in preparing various chemical substances. Besides this, the treatment of the gas purifying agents is of considerable importance, and it will come as a surprise to some readers to find how many are the chemical substances derived in this way.

Electric Light Fitting. By S. C. Batstone, A.M.I.E.E. (Whittaker and Co., London, 1914; 317 pages, 238 illustrations.)

In the preface the author states that his chief aim is to confine himself entirely to "the practical side of the question," so that little is said as to the decorative aspects of lighting. The illustrations are clear and the book follows a well-ordered sequence. The initial chapter deals with simple laws and units of measurement, and subsequent sections of the book are devoted to conductors, conduits and casings, switches, holders and fittings, lamps, shades and reflectors, house wiring, private plants, meters, stoves, &c. The chapter on switches is comprehensive, and the diagrams descriptive of house-wiring are easy to follow.

In the chapter on fittings and shades we should like to see a little more said as to their development with regard to illumination, particularly the design of prismatic and metal reflectors, with a view to concentrating and distributing the light on a pre-arranged plan. Some of the best types are not illustrated. We notice a slip on p. 169, where the French unit of light is spoken of as the "cared" (carcel?): at the present time both Britain and France use the same so-called "international" candle.

OTHER PUBLICATIONS.

The Proceedings of the Physical Society, Vol. XXII., Part III., contains two interesting papers by Mr. C. C. Pateson and Mr. B. P. Dudding on "The Unit of Candlepower in White Light" and "The Estimation of High Temperatures by the Method of Colour Identity."

The Simple Character of of the Yellow Sensation. By F. W. Edridge-Green. (Reprinted from the *Journal of Physiology*, Vol. XLIX., No. 4, May 12th, 1915.)

Reprinted from the *Transactions of the Illuminating Engineering Society, U.S.A.* :—

Artificial Daylight, Its Production and Use. By M. Luckiesh and F. E. Cady.

The Application of the New High Efficiency Tungsten Lamp to Photography. By M. Luckiesh.

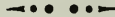
Safeguarding the Eyesight of School Children. By M. Luckiesh.

SITUATION WANTED.

An Engineer with long and successful experience in the Lighting Industry desires situation as General Manager or other responsible position with big concern connected with low or high pressure gas. Exceptionally well introduced among the largest industrial consumers in this country, and can influence large contracts. Inquiries should be addressed—A.B., c/o The Illuminating Engineer, 32, Victoria Street, London, S.W.



TOPICAL AND INDUSTRIAL SECTION.



[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.]

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

SIEMENS BROS. DYNAMO WORKS, LIMITED.

Note New Address for Sales and Advertising Department.

The Sales and Advertising Departments of Messrs. Siemens Brothers Dynamo Works Limited, Incandescent Lamp and Fittings department, Dalston, have recently been transferred to 39, Upper Thames Street, E.C. From this address the combined lamp and supplies business will in future be controlled. The re-arrangement has been made essential by the rapidly-increasing turnover of Wotan and Tantalum lamps. Extensions in the manufacturing departments have been accomplished from time to time, and it will be remembered that exceptionally large premises at Shacklewell Lane were occupied some three years ago to provide store accommodation for the large stocks held by the Company. Although this released a certain amount of space and temporarily eased the situation, the introduction of new types of lamps, including gas-filled lamps, demanded that further extensions should be made. As a result, Dalston Works will now be devoted solely to lamp manufacture, and the output correspondingly increased. Apart from these considerations, it is hoped that the centralisation of the lamps and fittings selling organisations will prove to the convenience of their numerous customers.

All correspondence relating to Dalston material should be addressed to 39, Upper Thames Street, E.C.

CONTRACT ACCEPTED.

Messrs. Siemens Bros. Dynamo Works, Ltd., have received an acceptance of their tender for the supply of Wotan and Tantalum lamps from the Pontypridd U.D.C. for the ensuing twelve months.

"EDISWAN" KINGOLITE CANDLE LAMPS.

We are informed that the Kingolite Co., Ltd., of Pyke House, 19, 21, 23, Oxford Street, and Soho Square, W. (of which Mr. William J. Owen is Managing Director), have disposed of their business in electrical accessories and silk shades to the Edison & Swan United Electric Light Co., Ltd.

The Kingolite Co.'s Works, together with practically the whole staff, have been transferred to Ponders End, while Mr. Owen, having accepted a position with the Edison & Swan United Electric Light Co., Ltd., continues to superintend the business he has been instrumental in establishing.

SHOOTING COMPETITION BETWEEN TWO LEADING ELECTRICAL FIRMS.

A friendly shoot between the "Ediswan" Rifle Club and a team from Siemens Rifle Club was decided on the "Ediswan" Range last Saturday, June 26th. There was a very good muster, and many well-known names in the electrical field were present.

Siemens put 17 men in the field, including Mr. Holmes (Sales Manager), Mr. Hicks (Assistant Sales Manager), and Mr. Pryor (Hon. Secretary to the Club).

"Ediswan" team were equal in number, and included Messrs. Child and Elliott (Joint Sales Managers) and Mr. Corbett (Hon. Secretary).

The shoot resulted in a win for the home team by 1,284 to 973.

After the shoot the party, of nearly 50, adjourned to the Staff Café for tea, and a vote of thanks to the hosts was proposed by Mr. Holmes, and responded to by Mr. Elliott, after which the latter presented the prizes.

Having taken tea, another match, of six a side, was decided in favour of the "Ediswan" men, by 518 to 492.

YE OLD MITRE TAVERN.

YE Old Mitre Tavern in Ely Place, near Holborn, is one of the oldest taverns of London, though, strange to say, it is not often mentioned by antiquarians.

It stands on the site of the Bishop of Ely's garden, which was demolished in 1545, and the tavern actually dates back to 1546. One curious feature is a tree trunk, which supports one corner of the building, and may be seen from the outside. It is said to be the remains of a fruit tree which actually stood once in the Bishop's garden.



FIG. 1.—An exterior view of the Tavern taken entirely by artificial light. Note the antique form of lantern.

A curious circumstance is that the space immediately adjacent to Ely Place, in which the tavern stands, still remains in the diocese of Ely. We believe we are correct in stating that no rates are paid to the authorities in London, and that all payments are made direct to

the Ecclesiastical Commissioners in Ely. In a sense, therefore, the neighbourhood forms part of the County of Cambridgeshire and not the County of London. We understand that the City Police do not enter this area unless specifically requested to do so, and their duties are mainly exercised by the beadle, appointed from Ely, who carries out the functions of the old night watchman, making his rounds at intervals during the night and calling out the hour.

The building has lately been restored, and particular care has been taken by the architect, Mr. W. F. Foster, M.S.A., P.A.S.I., M.R.S.I., to retain the period. From the lighting standpoint the attention paid to the fixtures is interesting. The lantern shown in the foreground was specially designed to the correct style, and the oak panelling, furniture and lighting fittings in the interior have also been designed to special care. Attention may be drawn to the old oak chairs and tables and the iron work of the grate which is strictly true to period.

The curious chandelier hanging from the beams of the ceiling has also been specially designed to imitate the old conditions. The electric candles are mounted at the four corners of a massive wooden cross carried on a heavy chain and hook. The only somewhat incongruous element is the fact of electric candles being used, but in these modern times it is not in human nature to retain waxed candles! We may mention that the contractors responsible for carrying out the lighting were Messrs. Grant & Taylor, of Queen Victoria Street.

The two photographs reproduced herewith were taken entirely by artificial light, and the subject is certainly a



FIG. 2.—Interior view in Ye Old Mitre Tavern. The furniture, chandelier, and ironwork in grate have been specially designed to suit the period.

difficult one. At one stage in the proceedings an overcoat was hung over a powerful public light in the foreground, the presence of which threatened to

prejudice the result owing to the long exposure. In the circumstances the photographs may be considered very satisfactory.

THE MOORE LIGHT IN SPAIN.

A BOOKLET issued by the **Luz Moore Artigas C.A.** (Madrid) summarises the operations of this company in Spain. The booklet contains a variety of illustrations showing the application of the Moore Light for spectacular lighting outside shops, in factories and in the Royal Palace at Madrid. In the accompanying two illustrations we reproduce two of the most interesting of these views. Fig. 1

shows the reception room in the Palace illuminated by a pattern of Moore tubes on the ceiling, Fig. 2 the use of system in the form of indirect cornice lighting in a room with several handsome pictures.

Particulars are also given of several notable improvements in the Moore tube. One of these is the invention of an apparatus for locating small leakages in the tube, which, it is stated, can now be detected immediately, whereas previously six or seven days' delay would often be necessary.



FIG. 1.—Reception Room of the Royal Palace, Madrid, lighted by Moore Tube on ceiling.

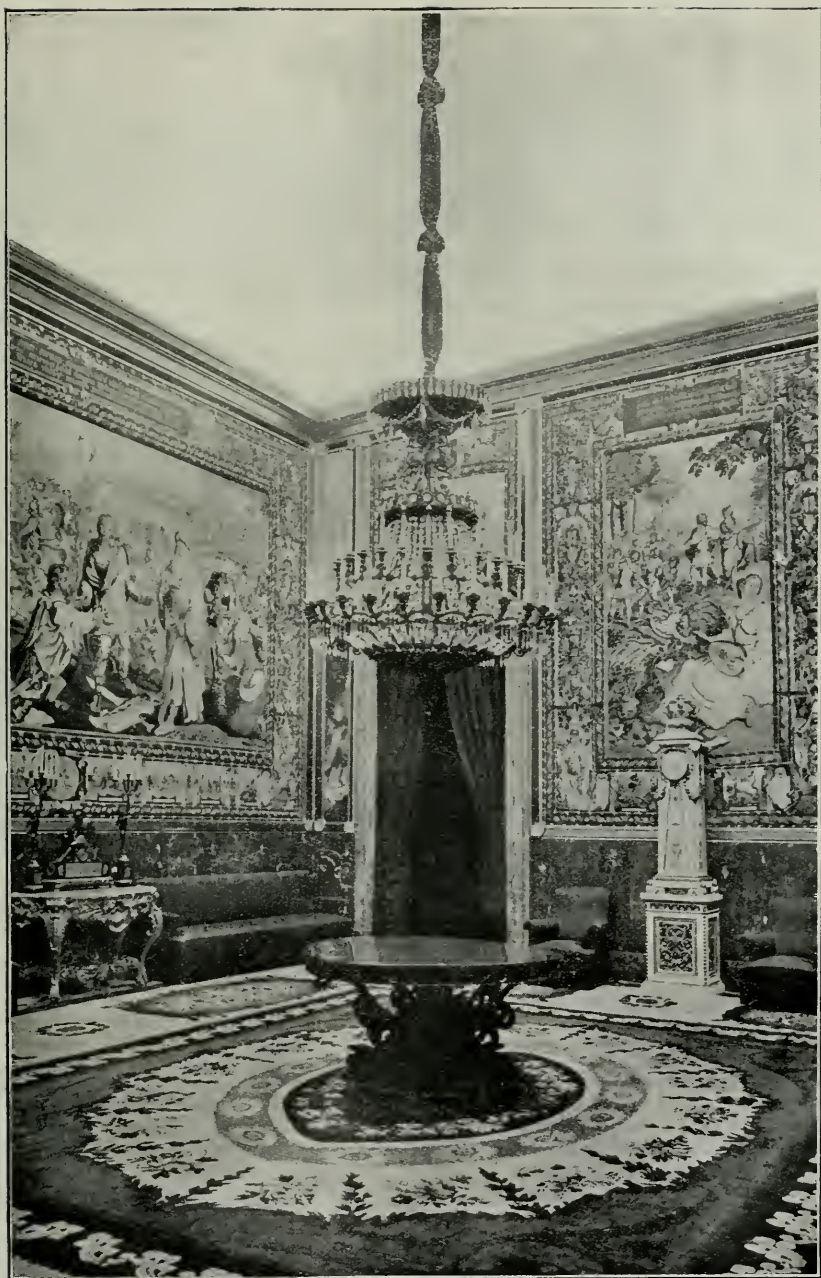


FIG. 2.—Indirect Cornice Lighting with the Moore Tube (Royal Palace, Madrid).

The second discovery is the doing away of the gas compressor feeding the tube, which has hitherto considerably limited the scope of operation of the system.

Yet another invention involves the superimposing of a high harmonic discharge over the ordinary alternating P.D., by which means the colour of the light can be considerably modified and much more efficient results secured. As a result of this method tubes of any conven-

ient size and dimensions can be used, whereas a diameter of 45 millimetres was previously necessary. Letter-signs of all kinds can now be made, and tubes of low consumption are available. Finally, by the use of the rarer gases, it is possible to avoid to a great extent the catalytic absorption of gases by the electrodes and to secure a specific consumption of only one-third of that previously attained.

Half-Watt Lamps.

New Types and Reduced Prices.

Recent leaflets received from the chief lamp-makers contain particulars of a variety of half-watt lamps. It is interesting to note the different methods of arranging the filament now in vogue. New sizes of the lamps are available, and prices have been reduced. We note that 60-watt lamps can now be had for pressures from 100 to 130-volt and 100-watt lamps for 200 to 260 volt circuits.

Osram Atmos Lamps.

The General Electric Co., Ltd., send us a new leaflet descriptive of the Osram half-watt lamps, or, as they will in future be termed, "Osram Atmos Type Lamps." There is much to be said for the policy of calling such lamps by a name descriptive of their special manufacture, rather than their specific consumption. In the United States they are spoken of as "gas-filled" lamps.

Rise in Price of Glassware.

Messrs. Siemens Bros. Dynamo Works, Ltd., inform us that since June 1st, 1915, it has been found necessary to advance the list prices of fittings and glass ware by 10 per cent.

Ediswan Electric Service.

The Edison & Swan United Electric Light Co. have sent us a copy of the second issue of their booklet bearing the above title. The booklet contains a readable account of various Ediswan novelties, such as Dimmer Switches, Fans, Lighting Fittings, &c.

An amusing incident—the arrest of one of the staff who had arranged to take a photograph of the New Glass House—is mentioned. The best of the joke was, that the arrest was made on the information of another employee on the lookout for spies. Needless to say, the

photographer was soon identified and released, and, in the words of the article, "an entente cordiale" between the prisoner and the constables was established.

The G.P.O. has accepted the tender for a six months supply of "Royal Ediswan" (Tungsten) Drawn Wire lamps.

THE SOCIETY OF BRITISH GAS INDUSTRIES.

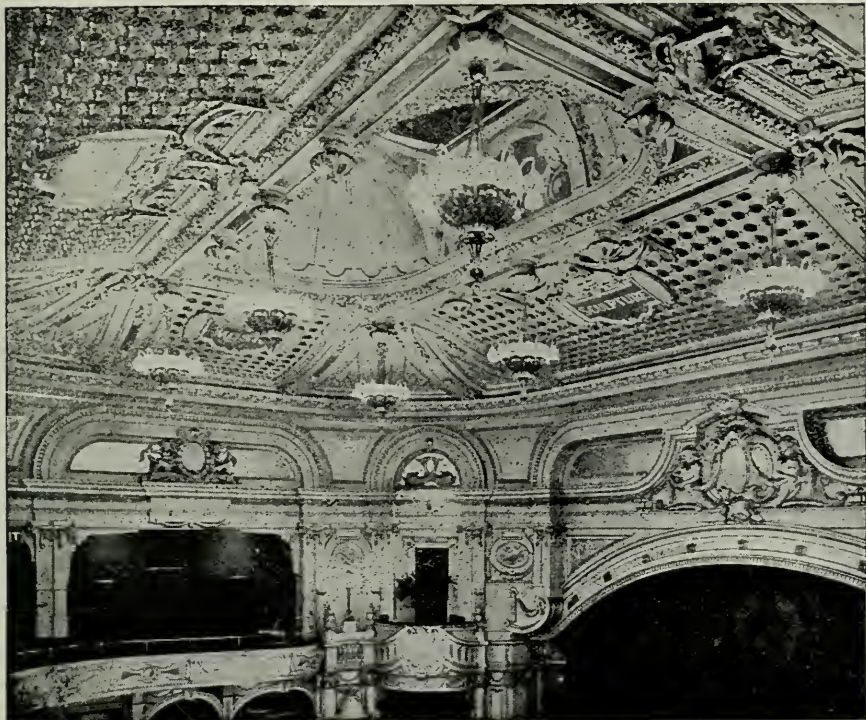
At the Annual Meeting of the Society of British Gas Industries in March, Alderman F. Templer Depree, the Chairman of the Council, gave an interesting account of the activities of the Society during the past ten years.

The movement dates from December, 1904, when a suggestion was thrown out in a leading article in the *Journal of Gas Lighting*, and taken up by Mr. Charles Clare. The central idea was to form a closer association between the engineers who produce the gas and the men who arrange for its distribution and use. The first meeting of the Society took place in March, 1906. Alderman Dupree referred to the series of distinguished Presidents from Mr. Dugald Clerk, F.R.S., to Sir Alfred Keogh, K.C.B., LL.D. An interesting analysis of the progress in the industry during these ten years was also made. One of the most striking episodes has been the rise of high-pressure gas lighting, but in the manufacture of gas, and in its use for heating and cooking, there have also been great strides.

At the present time the question of coal-tar dyestuffs fills an important place. The review concluded with a comparison of the make of the chief gas companies in 1904-5 and 1914-15. The outputs in cubic feet of the two largest concerns are as follows:—

	1904-5.	1914-15.
Gas Light and Coke Co.	21,902,357,000	29,633,586,000
South Metropolitan Gas. Co.	12,219,174,000	14,097,252,000

THE LIGHTING OF THE FINSBURY PARK EMPIRE.



Auditorium (ceiling) lighting of the Finsbury Park Empire.
(Proprietors : Moss' Empires, Ltd.)

In a modern Music Hall or Cinematograph Theatre light plays an important part. The stage, being the central point of interest, must be more brightly lighted than the auditorium ; in a Cinematograph Theatre, particularly, where the lights are turned on and off at such frequent intervals, the method of gradually diminishing the illumination desires special attention, and suitable " dimmers " are now almost invariably used.

The Finsbury Park Empire is lighted throughout with Mazda Lamps and B.T.H. Veluria reflectors. As will be seen from the above illustration, the ceiling carries a series of chandeliers thus equipped. The lighting units, softened as they are, are out of the direct range of view, and the effect is considered very pleasant. Further particulars of Mazda Lamps and Veluria Glassware can be obtained on application from The British Thomson-Houston Co., 77, Upper Thames Street, London, E.C.

GLASGOW SMOKE ABATEMENT EXHIBITION.

To take place in the Exhibition Hall, New City Road, Glasgow, from Thursday, Sept. 23rd—Sat. Oct. 16th, 1915.

This coming Exhibition is the third of its kind held at Glasgow, and on the last occasion no fewer than a hundred thousand visitors passed through the turn-stiles.

The forthcoming Exhibition will be under the patronage of the Glasgow Corporation and the local branch of the Smoke Abatement League. There will be exhibits of apparatus for heating, lighting, and cooking without smoke, and gas and electric current will be supplied to exhibitors free of charge. Lectures and demonstrations will be given daily.

Those interested should apply to the Manager, Mr. James M. Freer, 38, Bath Street, Glasgow.

OUR BLINDED SOLDIERS AND SAILORS.

The National Institute of the Blind, which has already done so much for the sightless in peace time, recently placed at the disposal of blinded soldiers and sailors a Convalescent Home at Brighton, where they are sent for any rest or change during their period of training at St. Dunstan's Hostel, in Regent's Park.

Here blinded soldiers are taught Braille reading, writing, typewriting, &c., and are even trained in such occupations as carpentry, boot-repairing, massage and telephony. An attractive little booklet shows how the soldiers are helped to indulge in such recreations as boating on the lake.

We feel sure that all our readers will appreciate the splendid work that the Institute is doing, and sympathetically regard the appeal for help now being issued by the President and Hon. Treasurer, Mr. C. Arthur Pearson. Further particulars can be obtained on application to the National Institute for the Blind, 224-8 Gt. Portland St., London, W.

PERSONAL.

We regret to hear that Mr. Ralph P. Hulton, who was formerly North Country representative of Holophane, Ltd., has succumbed to wounds received in the operations in the Dardanelles. immediately after the outbreak of war Mr. Hulton enlisted in the Engineer Section of the Royal Naval Division.

—o—

We note that Mr. Eric. D. Stokes, son of the Chief Inspector of the South Metropolitan Gas Co., who is also known to readers as a Member of Council of The Illuminating Engineering Society, has been granted a commission as Second Lieutenant in the 3rd Battalion of the 6th City of London Rifles.

Established
1885.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.

Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES

Of Life Assurance, with Various Options

All Classes of Insurance Business Transacted

CHIEF OFFICES:

General Buildings, Perth, Scotland.

General Buildings, Aldwych, London.

General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, July, 1915.

	PAGE
Accidents in the Streets, and Diminished Illumination	300
Arc Lamp Electrodes, Improved Type of	304
Cinematograph Work, Use of Light in	310
Drawing Room, Lighting of a	314
Editorial L. GASTER	293
Illuminating Engineering, Short Notes on :	
Illumination of Signs and Building Exteriors by Projectors	315
Photometric Tests of Street Lamps in a Law Suit in Philadelphia—Colour and Heat— Coloured Light and the Modern Composer	316
Submarine Photography by Aid of the Quartz Mercury Lamp—Matching the Snow	312
A Daylight Sign—Signs at Railway Termini—Illuminating Engineering Society (U.S.A.) Changed Constitution	318
Panama Pacific Exhibition, Illumination of the .. W. D'A. RYAN	305
Reviews of Books :—	
An Introduction to the Study of Colour Vision J. HERBERT PARSONS	319
The Bye-Products of Coal Gas Manufacture K. R. LANGE	320
(Translated by Chas. Salter)	
Electric Light Fitting S. C. BATSTONE	320
Safety Precautions in View of the Reduced Public Lighting	301
Topical and Industrial Section :—	
Siemens Sales and Advertising Department, New Address—Kingolite Candle Lamps, &c.	321
Ye Olde Mitre Tavern	322
The Moore Light in Spain	324
Lighting of the Finsbury Park Empire	327
Glasgow Smoke Abatement Exhibition—Our Blinded Soldiers and Sailors	328
Insurance Coupon	329
Railway Carriage Lighting	330
Ultra-Violet Light on the Eye, Effect of W. E. BURGE	303
Visibility Problems in War J. S. DOW	302

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL

ACCIDENT FIRE AND LIFE

ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.

GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.

F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

RAILWAY CARRIAGE LIGHTING.



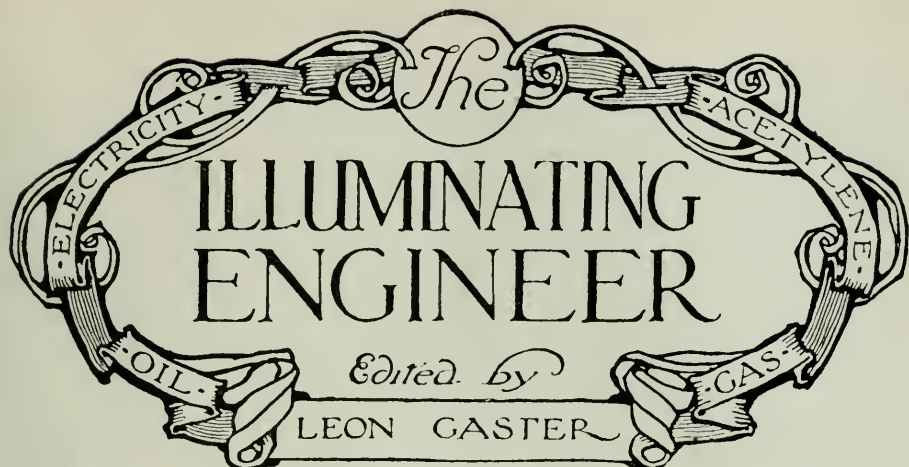
In view of the great amount of attention which the subject of the correct illumination of railway carriages has recently been receiving at the hands of the lighting engineers of railway companies and others, the accompanying illustration, which we have received from Holophane, Ltd., is of interest.

This railway carriage is one of a large number built by the Metropolitan Carriage Wagon & Finance Co., Ltd., at Saltley, Birmingham, for the Central Argentine Railway.

The overall dimensions of the carriage are approximately 66 ft. by 9 ft. It is divided into two compartments, each

25 ft. by 9 ft., and both compartments are installed with four 12-in. Holophane Reflector Bowls (each equipped with two 40-watt lamps) down the centre of the coach, whilst on either side there are four Holophane Pines No. 3150 with 40-watt lamps.

The energy provided in this case is very liberal, enabling an illumination intensity of 6 foot-candles to be obtained uniformly over the whole reading plane. It is also stated that the soft and well-diffused lighting prevents any impression of glare—a point on which much emphasis was placed in a recent discussion on the subject at a meeting of the Illuminating Engineering Society.



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD
32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

Deliberation—then Organisation.

In our last issue we ventured to make a few suggestions regarding the Organisation of Science, and the avoidance of overlapping effort. Besides the newly created Ministry of Munitions we have now the two separate Boards of Invention assisting respectively this Ministry and the War Office, and the Admiralty; and a third Advisory Council on Industrial Research. We have also in progress a vast scheme of National Registration, the utility of which must depend radically on the judgment which with the returns of skilled labour are analysed.

All these are admittedly emergency measures, taken in order to meet the exceptional and momentous circumstances of the present time. There is every reason to hope and believe that they will accomplish most useful work; but as organisations these bodies are naturally less complete than those developed as a result of long and careful reflection and perfected by experience over many years. This point was excellently put by Lord Haldane in a recent article in *The Nation*. "The possession of ideas," he said, "is, in a vigorous people, the real source of organisation." In other words before we can organise we must have a clear and concrete conception of the purpose to be attained. Deliberation must precede organisation. We venture to think that those people who vehemently press for a sudden effort of organisa-

tion, without forming a detailed and clear idea of its purpose, know little of the elaborate scheme of things evolved through long and painful thought by our adversaries and gradually brought to perfection through many years. One point which will doubtless receive consideration from the authorities is the desirability of inter-communication between the various Councils. Probably many suggestions brought before the Admiralty Board of Inventions would be of interest to the Council assisting the Ministry of Munitions. Opportunities might therefore be provided for members of all the Councils to confer on matters falling within their special province as experts.

It is also worth while to inquire whether, at this stage, it would not be desirable to form some central body—something of the nature of the “General Staff” suggested by Lord Haldane—whose function it would be to survey the situation as a whole and to correlate the activities of the various departments organised for war. During the past few months we have suffered all the natural results of our unprepared state. We have seen in turn each aspect of the war receive prominence—first the need of men, then the need of munitions and men to produce them, then the dislocation of our wealth-producing capacities which pursuit of the first two objects entails. On the other hand we have certainly learned much by our experience, and are now in a better position to organise the resources of the nation on a scientific and far-sighted plan, such as might be developed by a central body capable of studying the pursuit of war and its consequences *as a whole*.

Not the least important function of such a body would be to reflect on the future—to consider what our condition will be when the war is over and we attempt once more to resume our normal life. We are aware that some people resent even the contemplation of this period, fearing apparently that by so doing we in some way weaken our capacity for present effort. We can only say that this disinclination to look ahead is characteristic of the weaknesses which revealed themselves in our past mental attitude but which, we hope and believe, we shall now take steps to remedy.

To a large section of the community there falls the duty of conducting the war in the field of battle; to others the equally important task of providing the combatants with the implements of warfare. But there are others whose gifts cannot be applied in any efficient manner to the actual fighting who could nevertheless render good service by making preparations for the future.

One vital problem for the consideration of such a General Staff would be the conditions of industries which are a vital asset to our national wealth and which must be safeguarded against permanent injury through the demand for men and interference with business organisation existing at the present time. To our mind an important principle to be kept in view in such cases is *the preservation of continuity*. It is inevitable that industries should suffer, but the weakening should not be carried to the point of exhaustion, and a framework for future effort and expansion should remain in being. This principle applies not only to commercial undertakings but to scientific, educational and technical organisations which act as originators of ideas, and stimulate industrial and national enterprise. Such institutions might, with proper guidance, do much to prepare the ground for the future—to pursue the deliberations which, as we have seen, are a necessary preliminary to future organisation.

Admittedly the coming of war found us in a large measure unprepared. Let us see to it that in the time to come we are not found even less prepared for peace.

Light and the Human Machine.

Machinery is of two kinds—human and mechanical. The last century saw the development of mechanical machinery to a high state of complexity and perfection, and requiring considerate treatment. Every engineer is aware that machinery which is left idle may suffer more than if in constant use and properly looked after; and conversely, that machines must be “nursed”—guarded against strain, improper use, and application to work beyond their power.

Far-sighted employers also appreciate the need for keeping their human machinery in good condition, as is shown by the improved hygienic conditions in the factory and the opportunities frequently provided for refreshment, recreation, and medical attention on the premises.

At the present time, when many factories are working long hours at great pressure, these facts should not be forgotten. There is sometimes a tendency to work a willing horse too hard and to omit proper intervals for recuperation. Physiologists have shown that, up to a certain point, the body can recover from fatigue; but if the effort is too severe or too persistent there may be permanent chemical and physiological changes which destroy to a greater or less degree the power of recuperation and prevent complete recovery.

The scientific researches of the late Frederic Winslow Taylor in the United States have shed a great deal of light on this problem, showing, in many instances, how by judicious intervals for recreation the day's output of work can be substantially increased and the efficiency of the human machine safeguarded against the results of excessive strain.

Especially should we consider the effect of the conditions of labour on the performance of work. In an article in the present number (pp. 335—338) some instances are given of the effect of improved illumination on the quality of work and output. We have frequently alluded to this point in the *ILLUMINATING ENGINEER*, and the great advance in factory lighting during recent years in itself shows that the manufacturer is becoming alive to the relation between light and work. Mechanical machinery, it is well known, suffers if the illumination is insufficient. Its parts cannot be seen and do not get properly cleaned; its efficiency is diminished and its rate of deterioration is increased. In the same way the human machine can only do its best when proper light is provided.

It is well known that this subject has been receiving the attention of a Departmental Committee appointed by the Home Secretary during the past two years and a recent editorial in the *Electrical World* draws attention to the efforts being made by various States in America to insert in their legislation some requirements regarding factory lighting. It is remarked:—

There seems therefore to be a wide field for the illuminating engineer in the assistance he can render where legislation of this kind is pending, and at the same time it seems apparent that the average factory owner will see for himself the many advantages of good light which, when properly viewed, form an influence almost as great as if not in excess of that normally brought to bear by legal requirements.

We are sure that when the Report of the Departmental Committee on Factory Lighting is issued it will be seen that full advantage has been taken of the experience of the illuminating engineer; and we are equally confident that any proposals which have in view the improvement of industrial lighting will be sympathetically received as a distinct economic advance by factory owners in this country.

The Lighting of the Panama-Pacific Exhibition.

In our last issue we dealt with an article recently published by Mr. W. D'A. Ryan on the Lighting of the Panama-Pacific Exhibition, now being held in San Francisco.

In such times as these it is curious to reflect that in San Francisco representatives of different nations are presumably still meeting together, and possibly even discussing the war in a more or less amicable manner. Equally remote from our present thoughts is the gorgeous and spectacular illumination which forms such a striking feature at the Exhibition. During the past few months we have become used to the diminished illumination of London and the vigorous suppression of all illuminated signs and spectacular devices. Many months may elapse before we can again turn our thoughts in this direction. But the methods employed in San Francisco appear to be so novel and interesting that they should not be overlooked by illuminating engineers even at the present time.

There have been many national and international Exhibitions during recent years, but the methods of illumination have been substantially the same; generally speaking they have shown little originality. The practice almost invariably followed has been to follow the outlines of the buildings with incandescent lamps, and the lighting in the grounds of the exhibition has differed little from which may be seen in any brightly-lighted thoroughfare. At the Panama-Pacific Exhibition special efforts were made to treat the illumination in a more novel and scientific manner. At an early stage in the proceedings Mr. Ryan and his assistants were planning the arrangements in co-operation with the commission of architects concerned in the building. The architectural plans and the lighting methods were worked out simultaneously and the whole scheme of illumination was contrived with a view to showing off the exteriors of the buildings to the best advantage by night.

The dominating feature of the lighting appears to be the illumination of the exterior of buildings by "concealed" methods. Instead of festoons of unscreened incandescent lamps the sources of light were arranged on artistic columns shaded by specially designed screens, carrying heraldic and other devices, and arranged to throw the light on to the face of the buildings. Considerable use is also made of batteries of searchlights, playing on the spires and domes of the buildings, the surfaces of which were in some cases specially designed to produce jewel-like effects. For the interior lighting use has also been made of indirect methods, such as lamps concealed in bowls and pedestal fittings, columns of fluted glass, and playing fountains. In many instances the lighting has been designed to symbolise the sentiments associated with the various Courts in the Exhibition (Court of Abundance, Court of the Universe, &c.).

It is difficult for those who have not had the pleasure of being present at the Exhibition to judge of the effects produced, but it would appear that a new precedent in exhibition lighting has been established and that the arrangements in San Francisco will furnish us with some useful suggestions when we in this country are once more able to devote our attention to decorative lighting.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

LIGHT AND THE HUMAN MACHINE.

BY AN ENGINEERING CORRESPONDENT.

Among the strongest considerations that can be urged in favour of good industrial illumination is the fact that light is a *tool*, as necessary to the carrying out of successful work as the actual machine which the operator employs. Neglect to utilise this tool to the best advantage may lead to unsatisfactory results in several ways.

In the first place we find a general recognition that neglect to provide a certain measure of illumination is conducive to accidents. In view of the many complex factors entering into this problem a statistical inquiry into the relation existing between illumination and accidents is by no means easy. Nevertheless in past issues of THE ILLUMINATING ENGINEER many data have been published which suggest that such a connection exists. One of the best known instances of such statistics is the well known chart derived from statistics prepared by the Fidelity and Casualty Company of New York, showing that the frequency of accidents in the dark winter months is considerably greater than in the summer; the curve in fact follows very closely the curve showing the proportion of daylight and darkness throughout the year.

Naturally a distinction must be drawn between the conditions in various classes of employment. For example some data were given about a year ago on the con-

ditions of employment in the iron and steel industry in the United States.* From these it appeared that in blast furnace work the frequency of accidents is practically the same by day and by night. But in the yards there are actually *twice* as many accidents at night as there are during the daytime. This is to be expected, for in the yards unskilled labour, for which very little artificial light is provided, is mainly employed, and the risk of accident through men falling and stumbling in such cases is proportionately greater. It is however highly probable that many other accidents, such as those arising from neglect of machinery, might be traced to defects of lighting. Mr. R. E. Simpson, in a recent paper before the Illuminating Engineering Society in the United States,† mentions an interesting incident:—

"The following incident which recently came to the writer's attention, illustrates the evils of "spotted illumination" and the danger to workmen if one of their number was afflicted with retinal asthenopia or temporary blindness, and shows how easy it is to overlook the real cause of an accident.

"Two men were at work in a shop lighted by electric incandescent lamps, equipped with obsolete tin reflectors

* *American Industries*, May, 1914.

† *Trans. Ill. Eng. Soc., U.S.A.*, Vol IX., No. 5, 1914.

suspended close to the work. The upper zone of the shop was in semi-darkness—a condition which became more pronounced to the workmen as they looked up from their work. Some sections of the machinery and floor were brightly lighted, while others were dim. In going to another part of the shop one of the men stumbled over a casting that was lying on the floor, and in an effort to save himself from falling he blindly put his hand on a belt-shifting rod which controlled the machine of another workman in the same row. This action threw over the belt and started the other machine. Fortunately no injury resulted, as the second workman had just finished a piece of work, and was engaged at the time in selecting another piece to put in his machine. It can readily be seen that a serious accident might have happened if the second workman had been engaged in adjusting the work in his machine as he would have been totally unprepared for the starting of the machine.

“The two men had a wordy war, the first workman blaming the man who had left the casting on the floor, while the second workman accused the first one of stupidity. Neither of them apparently considered the fact that the first workman was demanding an extraordinary performance from his eyes. There was marked difference in the reflecting values of the two parts of the castings on which he had been working. One part was highly polished and had a high coefficient of reflection, while the other part was a dull iron grey having a low reflecting value. The man's eye muscles had been under constant strain in an effort to adjust the pupillary opening to the light-reflecting conditions—the opening remaining relatively small, however, so long as the eyes were focused on the work. When he turned from his machine his eyes were compelled to adjust themselves to the change from a brightly lighted field of view to a dimly lighted one, and inasmuch as the eye muscles do not enlarge the pupillary opening as quickly as they contract it, he was labouring, for a time, under a serious handicap.

“If the incident had had a serious ending, the newspapers would have reported the accident as due to a fellow workman accidentally moving a belt shifter and thus starting up his comrade's machine; but an impartial and well-informed jury would have given improper illumination as the cause.”

To many people this may appear a trivial incident but doubtless it is by no means an isolated case. In almost every branch of factory work there are opportunities for accidents and the freedom from such is largely a matter of chance.

Most of those who have studied factory lighting have been impressed by the need of drawing distinction between the illumination required for the purpose of carrying on special processes (which varies naturally according to the character of the work) and the necessity for providing a general standard as a measure of safety. Attempts have been made to draw conclusions from practical experiences as to the order of illumination required from the latter standpoint. It may be noticed, for example, that in the discussion on the Lighting of Railways, which took place before the Illuminating Engineering Society in this country at the end of 1911, Mr. Haydn T. Harrison pointed out that on most railway platforms a minimum illumination of 0.25 f.c. was considered desirable—and this was borne out by figures presented by others with regard to the prevailing illumination on the platforms in the Tubes. Mr. Harrison also pointed out that in the lighting of goods yards an illumination below 0.25 f.c. causes delay in the handling of the goods, although, strictly speaking, this degree of illumination is only necessary at the points where they are being handled; similarly in shunting yards a minimum horizontal illumination of 0.1 f.c. was suggested as practicable.

Curiously enough the above value—0.25 f.c.—is very close to that suggested by Mr. R. E. Simpson as desirable in the interests of safety. In this connection he remarks:—

“From a safety standpoint as well as from a general illuminating engineering standpoint, intense local lighting,

as the sole means of providing artificial illumination in a factory, is undesirable. A minimum of two-tenths of a foot-candle should be provided in all parts of a factory where a moderate degree of local illumination is required. In plants where fine tool-work is done, and fine bench operations are carried on, so that intense local lighting is required, the minimum for general lighting should be one-half a foot-candle. This minimum is also essential in a shop filled with moving machinery, especially if the men are required to go from one part of the shop to another in the performance of their duties. Sharp contrasts between the intense local illumination and the low general illumination increase the hazards, because the employees, on account of their inability to see clearly, are apt to trip over obstructions in their path, or become caught in the machines or belts."

Naturally the illumination required for the purpose of carrying out work, as distinct from that needed from the standpoint of safety, varies much in the different industries. But in all cases the value provided for carrying out the work is very much above the safety minimum, of 0.2—0.5 ft.-candles, tentatively suggested by Mr. Simpson.

For example, the following figures were suggested by Mr. C. L. Eshleman* as typical of present practice in various factories:—

	Illumination (ft.-candles).		
<i>Carpenter's Shop:—</i>			
General	2.5		
Machinery	4.0		
Corridors	0.6		
Drafting Room	8.0		
Engraving	10.0		

Factory:—

General lighting (where individual drop lights are provided)	1.5
General lighting (where no individual lights are provided)	4.0
Local bench illumination..	4.0
Mechanical work (fine) ..	5.5
Pattern Shops	4.0

<i>Sewing:—</i>	Illumination (ft.-candles).		
Light goods	4.0		
Dark goods	8.0		
Spinning mills	2.0		
Typesetting	8.0		
Warehouses	1.0		
Wharves	1.0		

It cannot be gainsaid that the lighting of open yards is an exceptionally difficult problem. The same applies to ships. In the ship building trade, Mr. Simpson remarks, a large percentage of the accidents that occur are caused by falls, and the lack of proper lighting facilities is an important factor. "When a ship is building or being repaired, artificial lighting must be depended on, all the time, in almost every part of the ship. Generally speaking, adequate light is provided at the points where work is performed, but the lighting facilities from the working point through the ship to the shore are often neglected. The opportunities for falls are numerous, especially when the ship is being fitted out after launching. Open hatches, uncompleted and unguarded stairways, and gangways seldom, if ever, sufficiently lighted, are directly responsible for many serious and fatal injuries. If ship owners or builders would go to the slight expense of providing guard rails about stairways, platforms, bunker hatches, and openings into the hold, and see that these points are well lighted, the accident rate would be materially reduced.

Liability to accidents, however, is only one of the ills caused by insufficient industrial illumination. In a report presented by a Committee on Industrial Pathology appointed by the Royal Society of Arts as far back as 1885, Mr. White-Cooper, surgeon to St. Mary's Hospital, remarked that:—

"The vigour and energy with which work would be carried on in cool, well-lighted, well-ventilated apartments, would satisfactorily prove that attention to such points would be as conducive to the interests of the employer as to the health and comfort of the employed."

Some of the highly scientific researches on labour in factories carried out in the United States have shown that minute changes in practice may give rise to surprising improvements in output. At the present time, when many of our

* Proc. Amer. Inst. of Elec. Eng., Jan. 1913.

factories are working at great pressure the importance of this special field of study is well worth attention. We have yet to see in this country an exhaustive investigation of the part played by fatigue in limiting the efforts of workers. Physicians tell us that unduly overlong work at high pressure is uneconomical, and that better results could even be secured by allowing intervals for recuperation: in other words that *it is actually possible to work longer and accomplish less.*

Probably this applies particularly to highly skilled labour. If a workman is engaged on operations which require the utmost concentration of mind it is obviously desirable that his faculties should be at their keenest. One can easily understand how in these circumstances relatively small defects in the lighting arrangements will cause delay. Insufficiency of illumination, an inconvenient shadow, or a slight dazzling effect produced by reflection of light from a polished surface—all these causes may lead to a slip on the workman's part, or at least make him hesitate and lose time. If this is true how much greater must be the strain of attempting to carry out fine work and to make measurements to a small fraction of an inch, when the illumination is obviously inadequate. The illumination, therefore, should be regarded as an essential part of the machinery.

From the economical standpoint this view can be fully justified. It can be shown, for example, that in most cases the amount spent on lighting is a minute fraction of the cost of the machinery and the workmen's wages. Mr. C. L. Eshleman* mentions that in a large paper mill in the United States the loss on the output for 6 minutes is more than the cost of the lighting for 24 hours, the question of the cost of light is thus inconsiderable as compared with the efficiency of the workman. "Even if used during the entire working hours of the day, it will not represent more than one-half of one per cent. of the workman's wages."

Mr. Eshleman also gives some personal experiences on this point:—

"After leaving college, the writer entered the shop course of one of the large electrical manufacturers. Day-

light conditions in the factory were good, but the artificial lighting was not at all conducive to human efficiency. Winding coils on piece work basis he could earn \$2.00 per day. Later when changed to night shift, he could earn only \$1.10 during a corresponding number of hours. The same condition held with other men, so that we requested to be placed on hourly pay. We did not think about efficiency engineering of light at that time and apparently the foreman did not, because there was no change, and the company continued to run that department at 55 per cent. efficiency. In addition to that, it is recalled that only about 5 per cent. of the coils wound by daylight failed under high-voltage insulation test; while 10 to 15 per cent. of those wound at night were returned for rewinding."

There is no doubt that the influence of lighting is beginning to be realised by workers of the present generation, and that this alone will compel manufacturers to consider this point.

Mr. Franklin Thorpe, in his paper before the National Gas Congress in 1913, mentioned cases of weavers leaving one firm to go to another simply because of the lighting, and in one or two cases a strike was only diverted by hurrying on the lighting arrangements! Mr. Thorpe likewise contends that the cost of lighting is usually a small portion of the wages. For example in one instance the lighting costs are only .2 per cent. of the wages bill; the Insurance Act proposition in this mill worked out to 0.36 per cent.—nearly double the lighting costs.

This corroborative evidence of the value of good industrial lighting has a special bearing on the conditions in factories at the present moment.

Two points are being brought prominently before the public mind, the need for constant and energetic work to maintain the export trade of the country and provide munitions of war; and the necessity for thrift so as to avoid useless expenditure. But by "thrift" we do not understand parsimony in the provision of tools. The wise manufacturer will recognise that proper illumination, itself an important "tool," by facilitating the carrying on of work, pays for itself over and over again.

* *loc. cit.*

SOME EXAMPLES OF MODERN FACTORY LIGHTING BY GAS.

Readers will recall that in our May issue, an account was given of a recent paper by Mr. A. E. Broadberry, of Tottenham, on Factory Lighting, in which a number of modern high pressure gas lighting installations were described and illustrated.

ft.-candles being obtained. (These values agreed very closely to those calculated from the polar curves of the lighting units.) The reflectors are very serviceable in concentrating the light on the benches in the centre of the room, but at the same time there is a good illumina-



FIG. 1.—Showing the lighting by low pressure gas of a small workshop. Four 3-light units are used, the light from the inverted mantles being concentrated downwards by appropriate enamelled shades.

We now give a few additional examples of gaslighted factories. Fig. 1 is interesting as an example of up-to-date low pressure lighting in a small workshop. The dimensions of this room are 30 ft. 6 in. by 31 ft., and it is lighted entirely by four 3-light units, each of which consumes approx. 15 cubic feet of gas per hour. The illumination of the benches in the centre of the room was determined instrumentally, readings from 5·7 to 10·5

tion on the walls and blackboard. The photograph gives a good idea of the appearance of the room, and suggests that these illumination values, besides being considerably above what is necessary in the interests of safety, amply suffice for the work in hand. For these particulars, which are probably typical of many small workshops of this size, we are indebted to the courtesy of The Gas Light and Coke Co.

Figs. 2—4 refer to some low pressure installations in the district of the South Metropolitan Gas Co., to whom we are indebted for the photographs and data relating thereto. Fig. 2 is a view of a portion of the factory of Messrs. Jay's at Southwark, where a worker is seen at the machine table operating in straw. Near the machine is shown a Martens photometer used for measuring the illumination, which was found to be near 6 foot-candles. The worker was questioned as to the sufficiency of this illumination, and stated that it was ample for work on grey and black straw. In the gangway and staircase adjacent to this part of the room readings of 0.6 and 0.53 foot-candles respectively were measured at a height of 18 ins. above the floor—a figure which now probably may be considered quite sufficient from the standpoint of general convenience and safety in places where work is not actually in progress.

Fig. 3 shows a bench devoted to machine work in the same factory. Attention may be drawn to the row of pendant lamps, each equipped with a reflector concentrating the light on the bench.

Fig. 4 shows a common method of lighting staircases. In many factories there are stairways which receive little, if any, daylight, and from the standpoint of safety it is important that some appropriate artificial illumination should be available in such cases.

The other two illustrations show the Napier Motor Works, which are lighted with Keith high pressure gas lamps. The photographs are taken from the same position, by daylight and high pressure



FIG. 4.—Staircase and landing lighting.

gas respectively. Such comparisons are useful with a view to bringing out any differences in the arrangement of shadows, &c.; in this case there does not seem to be any very radical difference in this respect.

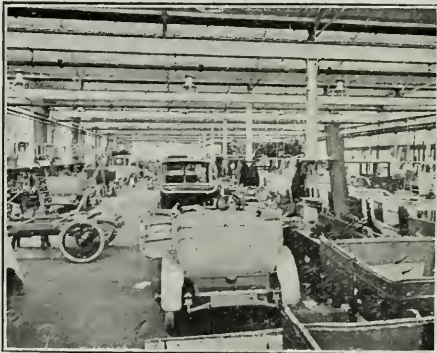


FIG. 5.—By daylight.



FIG. 6.—By artificial light
(Keith high pressure gas lamps).

Showing lighting conditions in the Napier Motor Works.



FIGS. 2 & 3.—Lighting of benches devoted to straw and sewing work at Messrs. Jay's Factory, Southwark.

Our last illustration, Fig. 7, shows a general view of a section of a factory of the Anglo-Swiss Nestle's Condensed Milk Co. The main lighting here is accomplished by 1,000 candle-power high pressure Keith lamps, situated at a height of 14 ft. 6 in. above the floor; small lamps giving 120 candle-power are to be seen in

at the various points where work is done. For example, at the mixer (edge of pan), 3·7 ft.-candles; on the feed and receiving ends of enrouver, 3·5 and 5·5 ft.-candles; on the packing bench, 3·2—4·5 ft.-candles. These values, we understand, are considered ample from the standpoint of carrying on work, and the illumination

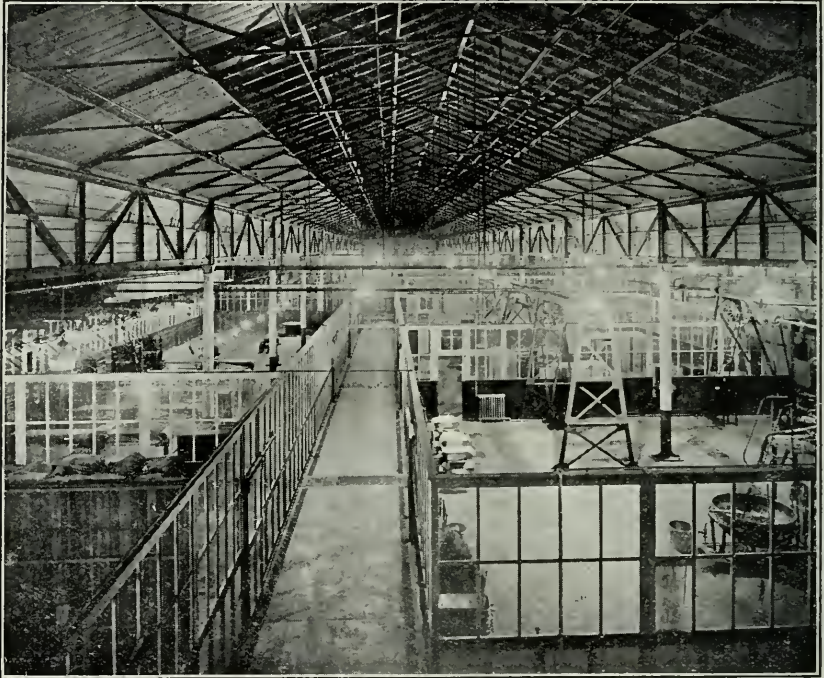


FIG. 7.—A view of the factory of the Anglo-Swiss Nestle's Condensed Milk Co., Battersea, lighted by Keith high pressure 1000-c.p. gas units.

one of the rooms on the left of the illustration.

The nature of this interior is interesting as showing how powerful lamps placed high up can be arranged to give a satisfactory general illumination, in spite of the presence of girders, belting, &c., which are apt to cause inconvenient shadows. The following figures are given for the illumination of this factory :—

On the floor values in the neighbourhood of 2 ft.-candles were measured. Considerably higher figures were obtained

on the floor level is probably a generous estimate of what is needed for general convenience in moving to and fro.

It will be observed that the 1000 candle-power are here used without globes, and merely surrounded by screens made of plate glass. In these circumstances the cost of maintenance is considerably reduced owing to the avoidance of globe breakages; there is also the additional advantage that if any plate breaks it can be easily and inexpensively replaced.

OVERHEAD SHOP LIGHTING.

The problem of lighting a large engineering factory is an important one at the present moment. The accompanying illustration shows the application of the overhead system of lighting in a large erecting shop. Lamps in focusing reflectors are spaced above the cranes, leaving a completely clear shop and

reflector and judicious spacing of the units.

The shop shown is 160 ft. long, 63 ft. wide, and 36 ft. high. There are 12 focusing reflectors, each containing a 400-watt lamp, arranged in two rows of six, and suspended approximately 33 ft. from the ground and above the cranes. The total consumption of electricity is thus



FIG. 1.—Overhead electric lighting in an erecting shop.

avoiding all the inconveniences of hanging pendants, &c. From the illuminating engineering standpoint it is also a distinct advantage to have the lamps high up out of the field of view, the inconvenience of glare being practically eliminated. In these circumstances it is usually desirable to flood the shop with an even, well-diffused lighting; success in this respect, and also in securing high efficiency, demands careful attention to the type of

4,800 watts, which is equivalent to rather less than half a watt per square foot of floor area. The illumination on the lighting plane is given as 2.2 foot-candles—quite a high value for this consumption of electricity—and is said to be extremely even.

For this photograph and information relating thereto we are indebted to the courtesy of the British Thomson-Houston Co., Ltd.

INDUSTRIAL LIGHTING BY MERCURY VAPOUR LAMPS.



FIG. 1.—By daylight.

Conditions of illumination in a Streatham workshop devoted to sewing.



FIG. 2.—By artificial light.

It is generally agreed that one of the most important factors in good industrial lighting is the arrangement of shadows. In this respect, probably, artificial light is almost invariably inferior to daylight, and it may be that unduly sharp shadows occasionally lead to accidents. It would be most interesting to obtain for typical factories a series of photographs comparing the conditions by natural and artificial light. We should then see in some cases how inconvenient shadows and contrasts exist which hamper the efforts of the workman and tend to slow down the speed of execution; in other cases, it is possible that artificial light, wisely arranged, might actually give better results than are obtainable with daylight.

The above two photographs, showing the illumination of a sewing room respectively by daylight and by Cooper-Hewitt

lamps, are interesting in this respect. The fact of the light being diffused over such a wide area in these lamps naturally gives rise to soft shadows, and this effect is well illustrated in the photograph of

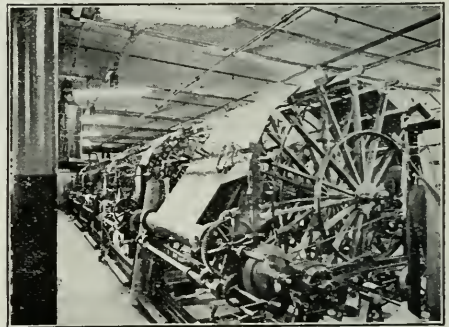


FIG. 3.—Silk mill illuminated by Cooper-Hewitt Lamps.

the silk mill shown in Fig. 3. The advantages of well diffused illumination are particularly evident in the case of complicated and intricate machinery, where

abrupt shadow-contrasts interfere with the inspection of parts.

On the other hand it must be recognised that in certain industries, especially those involving highly skilled "fine" work, general illumination, however well arranged, might be regarded by the operators as insufficient. In such trades as

watch-making, jewellery, and metal work, fine sewing, &c., the worker almost invariably prefers a local light which he can adjust and adapt to his requirements, and it is recognised that in these cases some degree of local lighting in addition to general lighting is often desirable.

SPECIAL PROBLEMS IN RAILWAY LIGHTING.

The lighting of railway stations, including platforms, goods yards, &c., was discussed at a meeting of the Illuminating Engineering Society about three years ago.* Engineers who are not railway men perhaps hardly realise the number of special lighting problems met with on a large railway, the conditions of illumination being often determined by considerations which would hardly occur to outsiders.

A special case in point is furnished by the lighting of "track scales and yards," which formed the subject of a recent paper before the American Illuminating Engineering Society by H. Kirschberg and A.C. Cotton.† The main source of revenue of most large railways consists in freight haulage, the carrying of passengers being as a rule a subsidiary source of income.

The method by which the weight of the goods passing over the line is registered, and the income from various sections of freight haulage estimated, is quite interesting. When a train of cars is made up, the cars are passed over a special section of the line termed the track scale, which may be from 37—83 feet in length, and of 300,000 lbs. capacity. This is built on a concrete foundation and communicates by means of levers to the scale beam in the small adjacent office built outside the section of the line, which is called the "scale-house."

The line approaching the track scale has a slight gradient, and each car is in turn allowed to run by gravity from the scale to the classification yard. As the car passes over the scale at a speed of 2·5 miles per hour the weighing is done. The operator in the scale house notes the indication of the beam before him and at the same time can look out through the window and observe any necessary particulars of the cars as they are passing.

* *Illum. Eng.*, Jan. 1912.

† *Trans. Illum. Eng. Soc., U.S.A.*, Vol. IX., No. 3, 1914.

The lighting must enable him to carry out both these sections of his work. The scale beam immediately before him should be illuminated by local lamps completely screened from the eye. The illumination must be sufficient for the figures on the beam to be read with ease, but there must be nothing in the arrangements of these lamps which would dazzle the operator's eyes and interfere with his view through the window of the cars outside. Seeing that he has to gaze out into comparative darkness it would probably be better for the room not to be completely lighted, merely enough illumination being provided to see the figures on the beam. The lighting of the track scale itself requires to be considerably higher than that used for ordinary track lighting, and in the illustration shown by the authors several special lamps are shown immediately under the projecting roof of the scale house so as to illuminate the track strongly and yet be screened from the eyes of the weighmaster inside the house. As the latter is looking from an illuminated room into a less brightly lighted area outside the lamps used to illuminate the track should, if possible, be screened so as not to interfere by their brilliancy with this view of the cars. Similarly these lights (and also any interior lights visible through the windows) should be so arranged that they do not dazzle the workers on the hump and clearance grades, as this might result in possible accidents to riders and car-cutters.

The functions of the illumination

outside the scale-house are summarised as follows :—

Safe cutting of cars at the hump.

Location of car at every point in its movement.

Clear sight of movement of every wheel on to the scale.

Reading of light weights and numbers on ends of approaching cars.

Reading of these weights and numbers on side of car on scale. (For this work a clearance of 2 ft. 11.5 in. (0.90 m.) is all that is allowed).

Reading of the light weights and numbers of the receding end of car, if not procured during either of the two aforementioned intervals.

Movement of the wheels off the scale.

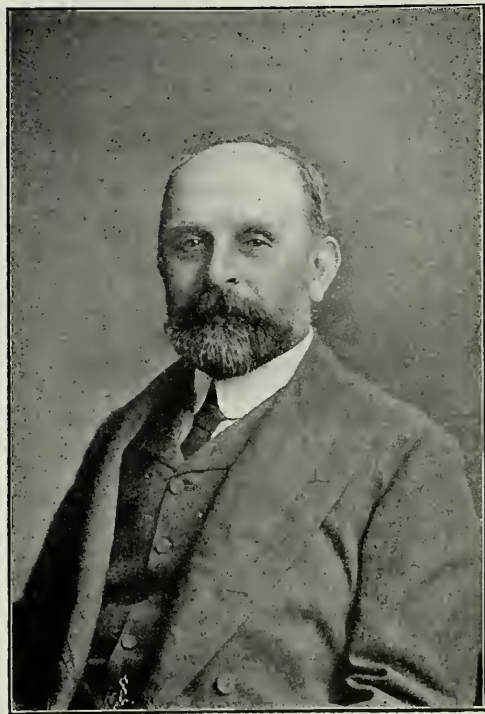
Clear sight of movement of car down the clearance grade in order to safely pass the next car over the scale.

Location of position of car on the clearance grade in order not to bump cars too hard when making up drafts of cars to go down the classification yard.

In the "classification yard," which is used for the purpose of connecting freight cars into particular routes and destinations, the usual method of lighting is to have a line of lamps down the centre of the yard and a line in each side. It is considered an extremely difficult problem to light a yard of this kind satisfactorily. It is not strictly speaking an ordinary open space and there are opportunities for special local lighting at various points, such as illumination of the switches at the head of the yard to facilitate the control of car movements from the switch tower.

EDWARD ALLEN.

BORN 1850 ; DIED 1915.



It is with great regret that we record the death of Mr. Edward Allen, Chief Engineer of the Liverpool Gas Company, on Thursday, July 15th. Mr. Allen held an important position in the gas industry. Born in Liverpool in 1850, he early entered the services of the Liverpool Gas Company, eventually becoming Chief Engineer in 1904. In 1914 he reached his fiftieth year of service with the company—an event which was recognised by presentations by the Council and staff, with whom his relations were always of a most friendly character. He occupied the Presidential chair of the Institution of Gas Engineers in the important year 1913, when the National Gas Congress and

Exhibition was held at Shepherd's Bush in celebration of the Centenary of Gas-lighting.

Besides being responsible for many technical advances in connection with gas Mr. Allen took a keen interest in the wider aspects of the application of science to industry, and the development of technical education. Shortly after the outbreak of the war, his services were accepted by the High Explosives Committee, where his professional knowledge was of considerable value.

As a Vice-President of the Illuminating Engineering Society Mr. Allen was in close touch with matters of illumination. He also represented the Institution of Gas Engineers on the National Illumination Committee of Great Britain, and was its first chairman. Only last January he presented the Annual Report of the proceedings.

Mr. Allen was a strong believer in co-operation. Although so prominently identified with gas his inherent fair-mindedness enabled him to make many warm friends in the electrical industry. He frequently expressed the view that there were openings for all illuminants, and that all could co-operate in educating the public to appreciate the value of good lighting; we have a vivid recollection of his genial speech to this effect, when replying to the toast of "Kindred Societies" at the Annual Dinner of the Illuminating Engineering Society two years ago.

In his dealings with colleagues and assistants Mr. Allen invariably displayed great tact and sympathy. All those who came in contact with him appreciated his lovable and kindly disposition, and his loss will be regretted by a wide circle of friends.

THE APPLICATION OF EDUCATIONAL METHODS TO THE REDUCTION OF ACCIDENTS.

By SYDNEY W. ASHE

(General Electric Company, Pittsfield, Mass., U.S.A.).

Presented at The National Association of Corporation Schools' Convention, June 9th-12th, 1914

The practical application of the teachings of psychology to accident prevention is after all the surest and quickest way of curing this industrial evil which in 1911 in this country exacted a toll of 13,625 lives. These deaths coupled with other injuries to persons represent an annual waste, according to conservative estimates of the American Red Cross, of at least \$250,000,000. This large sum does not include millions paid out in damage suits, surgical care, loss of wages or the subsequent decrease in efficiency of the injured.

Many companies in America in instituting safety work have followed implicitly the methods used with such success in foreign countries, such as Germany, in guarding all points of danger, hoping by this means to obtain equal success. Not realizing the fact that in a country like Germany, with its military training, its similarity of population, its sureness and thoroughness of operations of the working-men, its systematization, that conditions were entirely different from what they are in this country, they have not been able to obtain the same measure of success. This point is well illustrated by the following abstract from Technical Paper No. 30 of the Department of Interior, Bureau of Mines by Dwight E. Woodbridge on "Mine Accident Prevention at Lake Superior Iron Mines."

EFFECT OF SAFETY PRECAUTIONS ON NUMBER OF ACCIDENTS.

"Although it is quite probable that present standards would demand a larger number of

safety devices than in the past, and would require the company to exercise more care than formerly, one must still conclude that the installation of these devices, while of undoubted importance, does not reduce the number of accidents to the extent commonly supposed. There are other elements that must be given the most careful consideration. Of these, the chief is the education of the working-men to a sense of interdependence and individual responsibility."

Mr. Robert J. Young, Chief of the Safety Department of the Illinois Steel Company quotes as follows in connection with the value of educational methods for accident reduction.

"The question has been asked as to what efficiency in accident reduction can be acquired by guarding dangerous places. After going into the matter very carefully, I am led to believe that not more than 33½ per cent. of efficiency, can be gained by guarding machines, and in connection with this you will have the incidental advertising of safety that comes with the installation of the guards. Usually this efficiency will fall below 25 per cent.

"In talking with the United States Government expert in accident prevention, I asked this question. He placed the guarding of machines (not taking into consideration the incidental advertising of safety thereby) at not greater than 10 per cent. You will see, therefore, that if you are going to make a material reduction in your accident rate, it must largely be done through inspection and education."

The First Aid Department of the American Red Cross, under the direction of Major Robert U. Patterson, U.S. Army, and his associates, has done splendid educational work along preventative lines and first aid throughout this country. A large number of classes on First Aid to the Injured have been carried on throughout this country under their

supervision. As an illustration of their progressiveness during the past six months two of their equipped First Aid cars have visited Pittsfield, Mass., the home of the writer. Their physicians have given talks.

Dr. William H. Tolman of the American Museum of Safety, with the co-operation of the Brooklyn Rapid Transit Company and the Board of Education of the city of New York, have trained thousands of school children in safety methods. If this work is started in other cities as it has been, and continued for a few years, there is no question as to the wonderful benefit which it will be to our people and to our industries as a whole.

Many of our railroads, Y.M.C.A.'s, manufacturing companies, &c., have started First Aid classes, realising the great importance of educational work along preventative lines. In carrying on educational work on accident prevention we should not lose sight of two important things. No. 1, Carrying the work on continuously, and No. 2, Necessity of repetition.

Mr. Paul Lupke, in a paper on "Safety First" last week, before the National Electric Light Association, dwelt upon this latter point in the two following important abstracts.

"Newspaper men and other publishers and writers know that the people do not learn facts and arguments on any subject by one announcement, and that it needs constant effort of iteration and reiteration to send the matter home to the people it is wished to reach."—By Professor Wm. Howard Taft.

"The greatest factor operating toward the prevention of accidents is not the prevention device but the 'prevention spirit.'"—Power.

If we all realized in safety work that each employee is a human being with a human interest, has his family and home, no matter how humble his position may be, is usually ambitious and has a natural interest in his work and in the community, reads his daily paper, &c., in other words likes to live—we would see quickly that it is possible to obtain the co-operation of this individual in developing the safety habit providing we use educational means and choose the right methods. Habits of safety instilled into the minds of working people ultimately find their way into improved quality of goods manufactured or service performed. At our local works,

a large part of our output is "electrical transformers." These devices are placed in our electrical systems between the high voltage and the low voltage side. These devices not only serve to adjust electrical pressure so that it can be used in the house of the consumer for practical purposes but also act as a buffer for all disturbances from lightning and otherwise on our electrical transmission system. It is absolutely essential that this piece of apparatus be safe. It is safe and it is built to be safe for many years and one of the reasons it is safe is due to the habit of "personal safety" which is developed into the man at the bench or at the lathe who winds and builds this apparatus.

"Get the safety habit" is a good slogan, and to get this habit we must have our men accustomed to safe conditions, to using safe tools, to eliminating chances, to removing sources of danger, to be interested in having the best departmental safety record, to be willing to obey safety instructions and finally to be on the job when anything goes wrong.

Psychology teaches us that the reason loose habits are formed is that we are creatures of least resistance and choose such a path which brings the greatest momentary satisfaction. The reason a chance is taken and an accident results many times is therefore due to a mental feeling of unwillingness at this instant to use the extra effort to do what is right. To overcome this feeling of mental inertia we must therefore visualise in the individual at this particular instance a picture of the consequence of the accident if the chance is taken. To have this condition brought about, the individual about to take the chance must know of the danger and must have the safety habit. This habit can be readily developed by continuous safety educational work.

While many of the larger manufacturing and public utility companies have instituted safety measures, a number of the smaller companies have done little in this direction. In many places, dark passageways in need of efficient lighting are prevalent, besides utter lack of safety measures. Inadequate means of caring for injured and lack of safety educational work are also apparent. If these companies would only realise how much it is within

their power to accomplish in safety work with comparatively little expense, the country's yearly accident rate would be considerably reduced. Many excellent safety publications issued by various companies which they are only too glad to provide may be obtained free, which will give beginners in safety work many excellent suggestions.

Careful record of accidents, safety inspections, medical and physical inspection of new employees, and periodic inspection of old employees, emergency hospitals, first aid jars, a works paper co-operating with local daily papers and giving publicity to First Aid deeds, are all excellent adjuncts to any educational accident prevention campaign. The following synopsis gives a brief summary of a safety educational campaign which was recently instituted at the Pittsfield Works of the General Electric Company (U.S.A.), with the results which we have so far been able to obtain. Besides this work we have our Safety Committee and its chairman, who is a member of our Central Safety Committee for our entire organization. All of the educational methods used have been for the purpose of obtaining the co-operation of the working man himself, and it is gratifying to note that in this respect we have obtained a splendid response.

OUTLINE OF SYNOPSIS.

No. 1.—A system of weekly records was instituted whereby it was possible to study the character, the magnitude and the causes of the accidents occurring. This data was tabulated, was plotted on charts for the different departments and the conditions carefully analysed.

No. 2.—Records showed that our accidents consisted mainly of eye cases, burned feet in our foundry, electric shocks, punch press accidents, injuries from protruding nails, strains and ruptures.

No. 3.—At this time we had a Safety Committee, but this committee realised, in addition, that we needed educational work and some means of reaching our people individually in safety matters. It was, therefore, decided to start a safety bulletin or works paper and institute educational methods on a rather extensive scale. Besides doing this, we used the ordinary precautions of putting on guards such as an emery wheel hood which are absolutely essential.

No. 4.—We selected from our manufacturing organisation 178 men, consisting of foremen, assistant foremen, gang bosses, &c., representing the entire manufacturing division of our plant, and these men were given occasional lectures in

the company's time, on the Prone Pressure method of resuscitation, the care of shocks, the making of tourniquets, prevention and detection of tuberculosis, the use of the First Aid jar and a discussion on many forms of safeguards and causes of accidents. In 1913 we had five cases of electrical shock in which it was necessary to use artificial respiration. In each of these cases these men who were trained for emergency work acted quickly and saved the lives of the injured by the Prone Pressure method. One important case happening in our foundry made us realise how fortunate we were that we had trained our foremen in all departments. In addition to these meetings several private demonstrations were given to our girls by our trained nurse, for it was realised that it would be necessary, in case a girl was shocked, to raise the waist, cut up the corset strings, raise the corsets, before applying the Prone Pressure method.

No. 5.—While the lectures are being carried on we started a works paper, containing safety notes, surrounded with departmental notes and useful data.

No. 6.—Last winter we gave a series of lectures on experimental electricity in the evenings to our works people, having as many as a thousand present at a meeting. At each of these lectures ten minutes in the middle of the lecture was devoted to safety, covering, one evening, the use of goggles, another evening the Prone Pressure method, guarding of emery wheels, etc.

No. 7.—After a time we plotted a series of curves for the different departments, showing the ratio of accidents to employees covering such accidents as we report to the State. These curves showed the progress of certain departments, and indicated also other departments in which the rate had not been improved, such as the Order and Stores and Shipping Departments, departments that we had overlooked.

No. 8.—In the departments in which the rates were high, we divided the entire working force into groups of 30 and gave each group two illustrated safety talks, with the result that conditions immediately improved.

No. 9.—For the entire organisation we then started a form of friendly departmental competition. Each month the ratios were computed of the accidents occurring over the average number of employees. Each month a tabulation was compiled and published in our works paper showing the relative standing of the different departments. At the top of this list in black type was given those departments having a perfect record to date from the beginning of the year. Each month this list appears, and in time will, no doubt, give a very close approximation of the relative merits of the safety measures used in the individual departments. It is realised in this connection that in certain departments such as office force that the tendency for accidents is very slight.

No. 10.—Each month, when there is any special increase in the accidents in any particular department, we immediately start in giving a series of talks to the employees of this department, because it seems that every once in a while a department which has had a very good record

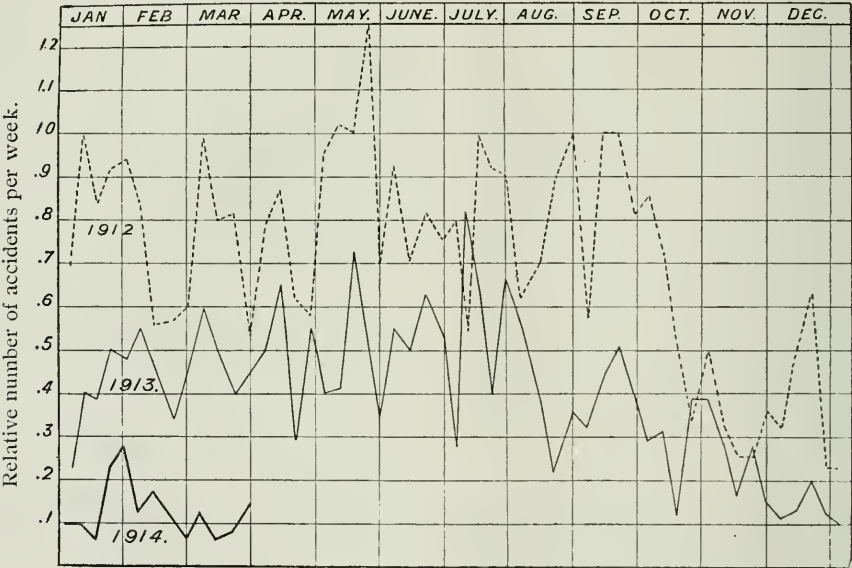
will suddenly have a very high record, and this gives an opportunity to go in and investigate. Usually there is some reason for this, such as changes in the personnel of the department, changes in the methods, and in easing up in safety precautions.

No. 11.—While the educational work was in progress the men were encouraged at the lectures to make suggestions and frank criticisms of our safety methods. Many useful ideas in connection with guards, dangerous places, &c., have been obtained in this manner from our men besides increasing the “personal safety habit.”

No. 12.—Before starting a series of lectures for a given department, careful inspections were made of this department to study the particular hazards of the work; such a place as the

creates a natural interest and obtains more loyal co-operation.

No. 14.—We started our educational work intensively in the early part of July last, when our accident rate for 1913 was at its highest point, and the attached curve shows the progress which has been made to date. The curve is plotted in terms of the ratio of accidents to the different weeks; the accidents occurring during the week over the average number of employees forms the ratio. This method was chosen so as to allow for the variation in the number of employees. Many other relations can be worked out, including such factors as accidents to man hours, ratio of total lost time to time worked, ratio of accidents to production, &c. The above ratio, however, has served our purpose, and we, therefore, expect to continue it.



Showing diminution in the accident rate throughout the year in the works of the General Electric Company, Pittsfield, U.S.A., during the years 1912, 1913 and 1914.

Shipping Department, for instance, requiring different safety precautions from the Foundry. These inspections afforded an opportunity for studying carefully the hazards in the different places and enabling many changes to be made.

No. 13.—When it was found that persuasion, inspirational work and educational work did not bring about improvement in safety conditions, rigid discipline was immediately instituted, with the result that the situation was instantly improved. In our Foundry, for instance, the use of goggles and moulders' shoes is compulsory when necessary. In our Punch Press Department the use of pliers to handle materials between the jaws of a punch press is insisted upon. We have certain rules for handling electrical circuits and also regarding the operation of cranes which are compulsory. Our policy has been, however, rather to lead the men than to drive them, for leading the men

CONCLUSION.

From the results of our experience we feel justified in stating that in a country like America there is an enormous amount which can be done towards the reduction of accidents by the use of educational methods. As a final adjunct to this work we would like to see a method instituted whereby some central association like the National Association of Corporation Schools, or the American Museum of Safety, or the American Red Cross would award a gold medal to every individual who performs an unusual first aid service, such as resuscitating an unconscious comrade by the Prone Pressure method. If this extra stimulus could be given there is no question as to the increase in stability which it would bring about to the whole safety movement.

ILLUMINATING ENGINEERING SOCIETY (U.S.A.)

NINTH ANNUAL CONVENTION.

The following is a draft of the preliminary programme of the ninth annual convention of the Illuminating Engineering Society (U.S.A.), which is to be held at the New Willard Hotel, Washington, D.C., September 20—23 inclusive. The papers which promise to be of an unusually interesting character, are to be distributed over ten sessions. One of the sessions will be devoted especially to the subject of street lighting; commercial, general, and laboratory papers will each be given three sessions. Inspection trips, a reception, and a banquet are among the entertainment features.

PROGRAMME.

Sept. 20—(MORNING).

Formal opening of Convention.

Address of Welcome; President's Address, etc.

Reports of Committees on Lighting Legislation, Nomenclature and Standards, and Progress.

(AFTERNOON)—*General Session.*

“Tests and Experiments in Connection with the New Commonwealth Edison Company Building,” by Messrs. W. A. Durgin and J. B. Jackson of the Commonwealth Edison Company of Chicago.

“Ship Lighting,” by H. A. Hornor, N.Y. Shipbuilding Company, Camden, N.J.

“Illumination Efficiency as Obtained in an Experimental Room,” by Ward Harrison, National Lamp Works of General Electric Co., Cleveland, Ohio.

(EVENING)—*Reception.*

Sept. 21—(MORNING)—*General Session.*

“Photometry with Portable Instruments,” by W. F. Little, Electrical Testing Laboratories, New York, N.Y.

“New Test Plate for Illumination Photometers,” by C. H. Sharp, Electrical Testing Laboratories, New York, N.Y.

“Incandescent Lamp Testing and Photometry,” by G. W. Middlekauff, Bureau of Standards, Washington, D.C.

“Street Lighting,” by F. A. Vaughn, consulting engineer, Milwaukee, Wisc.

(AFTERNOON)—*Entertainment, Trips.*

(EVENING)—*Street Lighting Session.*

“Gas Street Lighting” (author not yet announced), Welsbach Street Lighting Co.

“Arc Lamps for Street Illumination,” by H. E. Clifford, Harvard University, Cambridge, Mass.

“New Types of Incandescent Lamps and Their Relation to the Street Lighting Problems,” by W. H. Rolinson, Westinghouse Lamp Co., Bloomfield, N.J.

“Ornamental Street Lighting,” by T. I. Jones, Edison Illuminating Company of Brooklyn.

Sept. 22—(MORNING)—*Commercial Session.*

“How to Attack a Lighting Problem,” by W. R. Moulton, Consolidated Gas Electric Light & Power Company, Baltimore, Md.

“How Can a Combination Gas and Electric Company Render the Best Service to Customers,” by Messrs. S. B. Burrows and N. H. Potter, Public Service Corporation, Newark, N.J.

“Small Incandescent Lamps and Special Illumination Problems,” by R. P. Burrows, National Lamp Works of General Electric Company, Cleveland, Ohio.

“Lighting of Office Buildings,” by A. O. Dicker, Commonwealth Edison Company, Chicago, Ill.

Laboratory Session.

"Crova's Method of Colored Light Photometry Applied to Modern Incandescent Illuminants," by Messrs. H. E. Ives and E. F. Kingsbury, Physical Laboratory of the United Gas Improvement Co., Philadelphia, Pa.

"Differences in Threshold and Acuity Variations," by P. W. Cobb, National Lamp Works, Cleveland, Ohio.

"Visual Efficiency," by Messrs. F. K. Richtmyer and Howes, Cornell University, Ithaca, N.Y.

"Yellow Screens," by M. Luckiesh, Nela Research Laboratory, Cleveland, Ohio.

(AFTERNOON)—Commercial Session.

"The Flame Pilot Ignition of Incandescent Gas Lamps," by C. W. Jordan, Physical Laboratory of the United Gas Improvement Co., Philadelphia, Pa.

"Practical Illumination as Exemplified by Some Recent Installations of Incandescent Gas Lamps," by R. F. Pierce, Welsbach Company, Gloucester, N.J.

"Mercury Arc Lamps for Industrial Lighting," by W. A. D. Evans, Cooper-Hewitt Company, Hoboken, N.J.

"Relation Between Proper Illumination and Accident Prevention," by R. E. Simpson, Travelers Insurance Co., Hartford, Conn.

Laboratory Session.

"Retinal Sensibilities in Relation to Illuminating Engineering," by P. G. Nutting, Eastman Kodak Company, Rochester, N.Y.

"The Effect of Distribution of Light on Muscular Control," by H. M. Johnson, National Lamp Works, Nela Research Laboratory, Cleveland, Ohio.

"Effect of Various Wave Lengths of Radiation on Eye Cataract," by W. E. Berge.

Sept. 23—(MORNING)—*Commercial Session.*

"Artificial Illumination of Interiors," by David Crownfield, Pettingell-Andrews Company, Boston, Mass.

"Lighting of State, War and Navy Buildings," by W. E. Chapman, Assistant Superintendent, State, War & Navy Buildings, Washington, D.C.

"Lighting of Gymnasiums and Armories with Incandescant Lamps," by Messrs. A. L. Powell and A. B. Oday, Edison Lamp Works, Harrison, N.J.

Laboratory Session.

"The Effect of Surrounding Gas on an Incandescent Filament," by C. F. Lorenz, National Lamp Works of General Electric Co., Cleveland, Ohio.

"The Parabolic Mirror," by F. A. Benford, jun., General Electric Co., Schenectady, N.Y.

A paper (subject to be announced later) by C. E. Ferree, Bryn Mawr College, Bryn Mawr, Pa.

(AFTERNOON)—General Session.

"Artificial Illumination in Practical Photography," by C. E. K. Meeß, Eastman Kodak Company, Rochester, N.Y.

"Photographic and Visual Illumination Efficiencies," by L. A. Jones, Eastman Kodak Company, Rochester, N.Y.

"Production and Application of Ultra-Violet Light," by M. Von Recklinghausen.

"A Flux Method of Obtaining Average Illumination," by Messrs. F. A. Benford and H. E. Mahan, General Electric Company, Schenectady, N.Y.

Information regarding the convention may be had upon application to the General Office of the Society, 29, West 39th Street, New York, N.Y.

LECTURES ON HYGIENE AND SANITATION.

The Royal Sanitary Institute announce a series of lectures and demonstrations for Sanitary Officers to take place September—November, 1915, relating to municipal hygiene, public health disinfection, water supply, &c. The course also includes a series of seven lectures on meat and food inspection.

Another series of lectures is announced to assist School Teachers and others entering for the examinations in School Hygiene, commencing on October 4th, 1915.

Particulars can be obtained from the Secretary, Mr. White Wallis, Royal Sanitary Institute, Buckingham Palace Road, London, S.W.

SHORT NOTES
ON
ILLUMINATING ENGINEERING.

THE LIGHTS OF PARIS.

The *Edison Monthly* for July has a very apposite article on the lights of Paris. At the present time the illumination is far below what is associated with the

graph, showing a silhouette of one of the famous gargoyles of Notre Dame, presumably taken before the war began. Most characteristic of the Paris is the



“City of Light,” although the city is said to have already emerged somewhat from the deep gloom (physical, not mental!) that existed earlier in the campaign.

The adjacent illustration is reproduced from a highly spectacular night photo-

special festive illumination that takes place normally on July the 14th. At the present time these illuminations are naturally in abeyance, but we may hope that the time is not far distant when Paris will be the City of Lights once more.

MACHINERY PAINTED WHITE.

A NOVEL METHOD OF IMPROVING CONDITIONS OF ILLUMINATION IN FACTORIES.

According to *Popular Mechanics* the practice is being adopted in some factories in the United States of painting all machinery with a white oil-proof enamel. The ceilings are painted with the same material whenever possible, so as to facilitate the use of indirect lighting.

It is said that the light reflected from the machinery is most valuable in eliminating inconvenient shadows and diffusing the illumination. In one case it was found possible to take a photograph in such a workshop in one-seventh of the exposure that would have been required had ordinary unpainted machinery been used.

LUMINOUS GLOVES FOR TRAFFIC REGULATORS.

Attention was recently drawn in *THE ILLUMINATING ENGINEER* to the proposal that the curbs of pavements in London should be painted white in order to facilitate traffic—a useful suggestion in these days of diminished public lighting.

An even more remarkable step is said to have been recently adopted in St. Louis, where traffic policemen have been provided with white patent leather gauntlets, to be worn when directing traffic.* The glossy surface of these gloves is stated to reflect the rays of light directed against them from street and motor car lamps, rendering the extended hand of the policemen so conspicuous that it can often be seen by the driver before the figure of the policeman itself is discernible.

* *Popular Mechanics*, August, 1915.

In view of the present diminished lighting of the streets any devices of this kind are worth consideration.

THE EMPIRE FAIR.

An interesting event in 1917 is to be the organisation of a great exhibition devoted to the industries of the Empire. So far as human foresight can predict, there should be great scope for such an effort two years hence, and we gladly publish the following letter relating to the scheme:—

*To the Secretaries of Trade Associations
and Societies.*

SIR,

Re “The Industries of the Empire Fair.”

For the purpose of accommodating a Fair embracing all the industries of the Empire, an exhibition building is about to be erected in London, and will be completed by the spring of 1917. The area of the building will be approximately three times that of the largest exhibition building now existing in London, and will be known as the Palace of Industry.

A Fair of this magnitude being of national importance must not be promoted on the lines of a private enterprise. It is, therefore, suggested that the profits of the Fair be distributed amongst the firms taking part, in proportion to the space they occupy.

In order to protect the interests of the various trades, an Advisory Council is being formed, embracing representatives of the responsible Trade Associations and Societies of the country.

The Secretary of the Fair will be glad to receive the name of any Association or Society that has not already nominated an official to act on the aforesaid Advisory Council.

Faithfully yours,

WILLIAM GLASS.

Secretary to the Industries of the
Empire Fair,
Lincoln House, High Holborn,
London, W. C.

July 26th, 1915.

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

Picture Play Photography. By H. M. Lomas. (Ganes, Ltd., 85, Shaftesbury Avenue, London, W., 1914, 5s.; 169 pages, 52 illustrations.)

AN article on the applications of light in connection with cinematograph work recently appeared in this journal. The view expressed therein, that there is considerable scope for the lighting expert in this field, is illustrated by this readable little book, in which optical and visual problems are frequently discussed.

In the first chapters there is an interesting account of the development of the art of taking moving pictures. We see how their original application for scientific purposes was first appreciated, how presently they became a source of entertainment as well as instruction, and how of recent years new life was given to the industry by the representation of pictorial drama. Few outsiders realise the high technical skill and the peculiar artistic and dramatic instincts required to produce a good film. The author shows how the producer needs to appreciate the essentials of clear vision and the recording of movement. Scene lighting and the arrangement of lights play a great part in the production, the aim being to bring out the chief actors and prominent incidents and to relegate subsidiary details to the background. A chapter is devoted to lamps, reflectors, and dispersing screens, which are dealt with in a popular and rather summary manner. Some objection might be raised by an engineer to the rather crude explanations of electrical terms and to the statement that "the light from mercury vapour lamps is very similar to that from enclosed arcs." One would also like to have a more detailed analysis of the photographic efficiency of various illuminants.

The information on the arrangement of lamps and use of diffusing screens, &c., with a view to getting the correct shadow

effects is most interesting and is illustrated by some clear sketches. The author points out the danger of using over-brilliant unscreened light sources, the glare from which is apt to give a strained look to the faces of actors, and even to cause inflammation of the eyes.

The latter section of the book is devoted mainly to photographic and technical details. We notice that he advocates a judicious amount of diffused illumination in the dark room—not enough to cause any risk of fog, but sufficient to enable operators to see their way about. In the final chapter some curious instances of selective action on the part of photographic plates are given, such as the reappearance in the negative of a name which had been painted out on the hull of a ship, and the appearance of stripes on the coat of an animal, which were invisible to the naked eye.

The book is written in an entertaining and popular manner and should be interesting to many whose business is not closely identified with cinematograph work.

Gas Engineering and Gas Manufacture : A Review of the Institution of Gas Engineers. Edited by Chas. W. Hastings. (J. G. Hammond & Co., Ltd., City Works, Fleet Lane, London, E.C., 1915; 2s. net.)

WE receive Part I. of this review, the publication of which will be completed in six parts.

Part I. carries us from the foundation of the Institution in 1863 (as The British Association of Gas Managers) up to 1883, when the International Electric and Gas Exhibition took place at the Crystal Palace. To those in the gas industry the review should be of special historical interest, but many who are interested in general lighting questions will find this a complete summary of papers read before the Institution.

Mr. Hastings, who is known to our readers as a veteran in this field, has arranged his matter in a convenient and readable form. The text is printed on matt paper, and the portraits of Presidents on art paper insets. Looking through the pages of the Review we notice references to many interesting incidents and papers. We note, for example, the historic work of Mr. John Methven on flame standards of light, an interesting paper by Mr. Wm. Sugg on the Applications of Gas to the Lighting of Open Spaces and Large Buildings (in the course of which he refers to the celebrated experiments at the South Forelands Lighthouse), and a paper by Prof. A. G. Vernon Harcourt on the Pentane Standard.

Mr. Hastings has compiled a readable and interesting review, and we shall look forward to the appearance of the other parts in due course.

"Halifax, A Commercial and Industrial Centre," an Illustrated Handbook concerning the Town's Present Position and Future Promise. (Published for the Halifax Chamber of Commerce, Chamber of Trade and Advertising Club, by Sell's, Ltd., "At the Sign of the Sundial," 166-169, Fleet Street, London, E.C. Quarto, 2s. 6d.; by post, 2s. 10d.)

THIS booklet contains a summary of the position of Halifax as a commercial and industrial centre. Statistics are given showing the advantages of the locality as a residential area, and the book also contains many illustrations of features of interest and natural beauty around Halifax. There is also an account of the various engineering activities of the City, which have made great strides in recent years.

CORRESPONDENCE.

SHOP LIGHTING IN WAR TIME.

July 24th, 1915.

DEAR SIR,

In December last I sent a letter to your paper in regard to Shop Window Lighting in War Time, dealing with the amateurish attempts made by shopkeepers to conform to regulations. I drew attention to the much favoured method of wrapping tissue paper around bare lamps, and pointed out that not only was this very ineffective, but was a distinct source of danger, as witnessed by the large amount of badly scorched tissue paper seen.

The note of warning which I struck in that letter was amply justified in the Press this week, where it was stated that the L.C.C. Fire Brigade was recently called to an outbreak of fire caused by crinkled paper round electric lamp bulbs in a shop window. One is led to wonder

how many small outbreaks, not necessitating the attendance of the fire brigade, have been caused by this highly dangerous practice. The method I mentioned in my December letter was the scientific lighting of shop windows by means of concealed lighting units placed high in the window. This method ensures the effective lighting of the articles displayed with complete control to accord with the lighting restrictions of the Police—and has the additional merit of being safe and free from danger of fire. A large number of shops have been lighted on this approved plan and give absolute satisfaction to all concerned.

Yours very truly,

F. W. WILLCOX,

General Manager,
Lamp and Wiring Supplies Dept.,
The British Thomson-Houston Co., Ltd.

TOPICAL AND INDUSTRIAL SECTION.

— • • • —

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

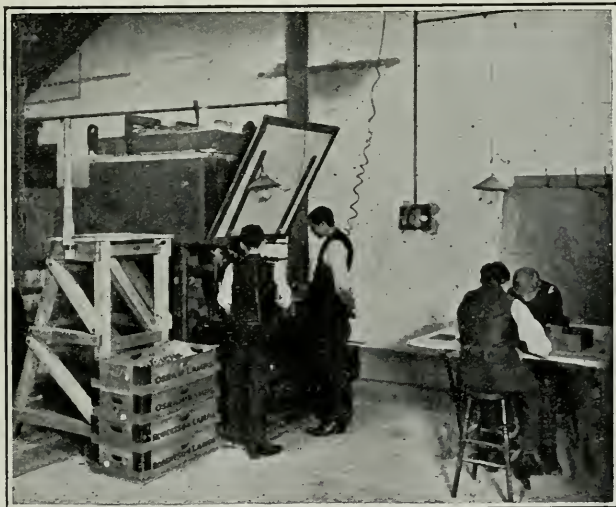
The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

BRITISH-MADE ELECTRIC LAMP CAPS.

Since the commencement of the war the lamp manufacturers in this country have been faced by various special conditions, arising from the disconnection with the Continent.

As an instance we may mention the

English cap-making plant to be published. We also understand that the Osram and Robertson Companies manufacture every other part of their incandescent lamps at Hammersmith with the exception of the glass bulbs which, as hitherto, are made at Lemington-on-Tyne. Both companies, therefore, are independent of any foreign source of supply.



manufacture of the caps of electric incandescent lamps. It has been generally assumed that these caps were invariably imports from abroad, and it is therefore of interest to learn that the Osram Lamp Works, Ltd. and the Robertson Lamp Works, Ltd. manufacture these at their Hammersmith factories.

The illustration shows part of the cap-making plant of these companies at Hammersmith, and we are informed that this is the first illustration of an

BLERIOT "NO-GLARE" LAMPS.

From Messrs. Bleriot, Ltd., we receive particulars of the Bleriot No-Glare Lamp for motorists, the essential principle of which is the use of a series of horizontal deflecting plates, for directing and modifying the beam. In this way the light is concentrated along the roadway, and at the sides of the road, where it is mainly needed, but the inconvenient upward rays are suppressed.

MAZDA HALF-WATT LAMPS.

A RECENT B.T.H. leaflet summarises in a readable manner some of the chief applications of Mazda Half-Watt Lamps, of which the following sizes are now available :—

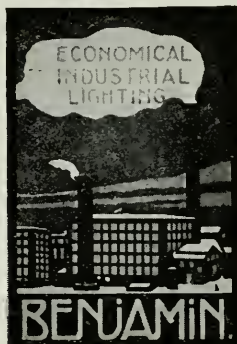
15, 30, 60 & 100 watts ..	25 volts
30 & 60 watts	50—65 „
60 & 100 watts	100—130 „
100, 150, & 200 watts ..	200—255 „

It seems but a short time since the advent of the ordinary 60-watt metal filament lamp for 100 volt circuits was considered a remarkable step. Now the leading lamp manufacturers are actually offering “Half-Watt” lamps in this size. Doubtless the time is not far distant when “Half-Watt” lamps in all the customary sizes will be obtainable.

The booklet has a striking cover and also contains particulars of fittings for these lamps. There are also photographs of installations in Selfridge's and of the effective display of these lamps in Leeds City Square.

—o—

BENJAMIN POSTER STAMP.



Above is a new Poster Stamp, one of three issued by The Benjamin Electric, Ltd., 1a, Rosebery Avenue, London, E.C.

—o—

EDISWAN “KINGOLITE” CANDLES.

IN all probability the candle is so deeply entrenched in the public mind as the traditional lighting unit that “electric candles” will be with us for a long time to come. A booklet describing the Ediswan “Kingolite” type, draws attention to the rigid character of this form of candle. The construction enables it to

be screwed down firmly without any danger of deviation from the perpendicular. Some attractive illustrations of sconces and portable lamps equipped with this candle are given.

We also note the Ediswan leaflet No. A 3112 relating to **Circuit Breakers.**

—o—

A WELL-LIGHTED TAILORY AND HOSIERY SHOP.

THE two views on the opposite page give an excellent idea of the lighting of a tailory and hosiery shop (Percy Harrison, Thames Street, Kingston-on-Thames). The upper illustration shows the appearance of the windows by night, the lower one the lighting of the interior. The entrance is effectively lighted by two Holophane Stiletto Bowls, and the contents of the windows by means of 32-watt lamps in F. 60 reflectors placed in the cornice, so as to be well above the goods and out of the direct range of sight.

The illumination in the window is about 4.6 ft.-candles, on the counters about 4 ft.-candles, and the general illumination in the shop about 3 ft.-candles. The interior gives the impression of being quite brightly lighted.

An advantage of this method of lighting at the present time is that, if desired, the lights can be readily screened, so as to be invisible from the pavement. The requirements of the Authorities can thus be complied with, without interfering with the illumination of the goods.

—o—

RAILWAY STATION LIGHTING.

We notice in *Electricity* an account of the lighting of the Caledonian Railway Co.'s station at Glasgow, which is now lighted by Osram 500 watt Atmos lamps.

It is stated that an improved illumination, as well as a considerable diminution in consumption of electricity has been secured. The horizontal illumination in the main hall is given as 2 ft.-candles maximum, with a minimum of 1.7 ft.-candles, while along the platforms the variation lies between 0.8 and 1.6 ft.-candles.

—o—

Messrs. Siemens Bros. Dynamo Works, Ltd., inform us that the company has again secured the contract for the supply of Tantalum Traction Lamps to the Borough of Leith for the ensuing twelve months.



Inside and outside views of Percy Harrison's Tailory and Hosiery Establishment (Thames Street, Kingston), lighted by tungsten lamps and Holophane reflectors.

(Photos. taken entirely by artificial light.)

THE NATIONAL PHYSICAL LABORATORY.

REPORT FOR THE YEAR 1914-1915.

The Report of the National Physical Laboratory for the past year again continues evidence of the useful work this Institution is carrying on. It is stated that 25 per cent. of the staff have joined the colours, and the presence of the remainder is very properly desired by the authorities in order to carry on the work of the laboratory. In addition to the ordinary work there have been special problems in connection with the war, the optical and aeronautical departments in particular being busy with problems of this kind.

Reference is made to the papers on photometry read by Messrs. C. C. Paterson and B. P. Dudding before the Physical Society during the year and to the systematic redeterminations of the Unit of Light, which agree with those made previously within 0.1 per cent. An

investigation is also being made into the coefficients of reflection of the white cards used with illumination photometers.

A very considerable amount of work has been done in connection with the Home Office Committee on Factory Lighting, and on the subject of Ships' Navigation Lights, &c.

We note that the financial results of the year have been adversely affected by the war. The proposed scheme of relieving the Royal Society of the financial responsibility in regard to the Laboratory, and obtaining additional support from public funds does not appear to have made material progress since the matter was brought to the notice of the Premier, in July, 1914.

Let us hope that one result of this unhappy war will be a fuller recognition of the value of scientific research, and that the National Physical Laboratory will receive the support it needs and deserves.

PERSONAL.

SUB-LIEUTENANT A. R. COURTENAY.

Ever since this country became involved in the now world-wide war, the General Electric Co., Ltd., has furnished a considerable number of officers and men—several of whom have already won distinction in the field. The newest officer recruit is Sub-Lieutenant A. R. Courtenay (late Acting Manager of the G.E.C. Publication Department).

Sub-Lieutenant Courtenay was always most enthusiastic and determined over everything that he took up, in addition he was most popular among those with whom he came in contact.

These valuable characteristics will now, doubtless, serve him in good stead in his new position. He was gazetted on May 20th Sub-Lieutenant in the Royal Naval Air Service, Armoured Car Aeroplane Support (Royal Naval Volunteer Reserve), and is now undergoing a course of gunnery.

Established
1885.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.

Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES

Of Life Assurance, with Various Options

All Classes of Insurance Business Transacted

CHIEF OFFICES:

General Buildings, Perth, Scotland.

General Buildings, Aldwych, London.

General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, August, 1915.

	PAGE
Accidents : Application of educational methods to the reduction of	S. W. ASHE 349
Correspondence : Shop Window Lighting in War Time ..	F. W. WILLCOX 358
Editorial	L. GASTER 331
Edward Allen	348
Empire Fair, The	356
Factory Lighting by Gas, Some examples of	339
Illuminating Engineering Society (U.S.A.) : Ninth Annual Convention ..	353
Industrial Lighting by Mercury Vapour Lamps	344
Light and the Human Machine	AN ENGINEERING CORRESPONDENT 335
Overhead Shop Lighting	343
Photographic Value of various Illuminants, The	347
Railway Lighting, Special Problems in	345
Reviews of Books :—	
Picture Play Photography by H. M. Lomas	357
A Review of the Institution of Gas Engineers : Edited by Chas. W. Hastings ..	357
Halifax : A Commercial and Industrial Centre	358
Topical and Industrial Section :—	
British-made Electric Lamp Caps	359
Mazda Half-Watt Lamps—A well-lighted Tailoring and Hosiery Shop—Benjamin Poster	
Stamp—Railway Station Lighting	360
The National Physical Laboratory (Annual Report)—Personal	362
Insurance Coupon	363
Gas and Munitions of War	364

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL ACCIDENT FIRE AND LIFE ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.

GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.

F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

GAS AND MUNITIONS OF WAR.

IN this journal there recently appeared an abstract of a paper by Mr. Broadberry describing some examples on the Use of High Pressure Gas Lighting in Modern Factories. At the present time, when so many factories are working overtime on Government contracts, and we are approaching the period of the year when artificial light will be mainly used there is a great demand for suitable lighting and manufacturers are quick to appreciate the important part played by good illumination in increasing the output, and maintaining the quality of work.

But apart from the use of gas for lighting factories of this kind, it has many special applications in munitions work, some of which were briefly mentioned by Mr. Thornton in his recent address before the Royal Society of Arts on the Use of Coal Gas for Industrial purposes. For example the heat treatment of shells—a matter of vital interest to our national existence at the present moment—is largely carried out by the use of gas furnaces. Even the huge shells are to-day being treated in this country in gas furnaces; one such furnace recently installed can turn out at one charge eleven of the giant naval armour-piercing shells—each shell weighing approximately one ton. Furnaces are also used for the welding of bayonet handles to their blades.

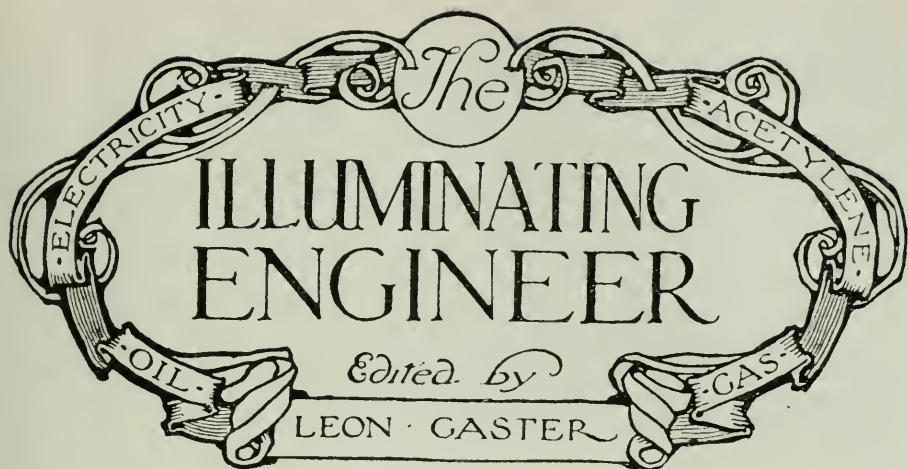
In some instances manufacturers have been enterprising enough to change the entire nature of their business at short notice. For example one firm which previously manufactured musical instruments found their trade in war time considerably lessened. Accordingly some

gas furnaces were ordered, and installed in a few days, and the same shop is now devoted to the tempering and colouring of small steel cartridge clips. Gas furnaces are also widely used in air-craft factories.

There are, however, many subsidiary operations, apart from the manufacture of actual weapons, which are quite as essential at the present moment. Take for example the finishing off of boots for the army by gas heated irons and the “treeing” (*i.e.*, making the boots take the exact shape of the last on which they are modelled); or again, take the making of peaked caps, in which use of gas irons plays a conspicuous part.

In the clothing industry millions of yards of material are singed by gas in order to burn off all the loose threads from the cloth. The cloth is then run through water to extinguish any sparks and is left in the water until it undergoes the subsequent operations of bleaching or scouring. Next there is the operation of “tentering” or stretching the cloth which is passed over a copper sheet heated by gas flames, thus driving out steam and moisture.

Lastly, we must not forget the value of gas for driving machinery. Small gas engines are widely used, and recently some very large engines have been developed. For example in the new pumping station of the L.C.C. at Barking there are seven 500 H.P. engines, each of which consumes about 7000 cubic feet of gas per hour and can pour nearly 100 tons of London sewage every minute into the sterilising tanks and purify it before it runs into the Thames.



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.

32, VICTORIA STREET, LONDON, S.W.

Tel. No. 5215 Victoria.

EDITORIAL.

The First Report of the Departmental Committee on the Lighting of Factories and Workshops.

An important section of this issue is occupied by the abstract of the above Report (pp. 371-390), the publication of which has been awaited with great interest. It makes an opportune appearance at the present moment. The workshops of the nation are very fully occupied. Many firms are working overtime on Government contracts and are making every effort to turn out their goods as speedily and efficiently as possible, and we are also approaching the period of the year when arrangements must be made for artificial lighting in the dark winter months to come.

Before commenting on the contents of the Report we should like to pass in review a few of the events of the past seven years leading up to the formation of the Committee. Industrial illumination has been much discussed on the platform of the Illuminating Engineering Society, and at various international congresses, and the wide notice given to these proceedings in the press has done a great deal to pave the way for scientific inquiry. In view of the millions of people engaged in the industries of this country, and the vast revenue derived from our export trade, the importance

of any measures likely to increase production and to promote the comfort and convenience of operators is evident.

The very first issue of the *ILLUMINATING ENGINEER*, in January, 1908, contained several articles on factory lighting. During this year there was appointed the Departmental Committee on Accidents in Factories and Workshops, a Committee whose work formed a useful preliminary to the appointment of the present researches on factory lighting.

In 1909 an important Report was issued by MM. Chantemesse and Walckener under the auspices of the Conseil d'Hygiene de la Seine.¹ This contained a useful summary of the legislation of various countries bearing on industrial illumination, and may be regarded as the first attempts to deal broadly with the subject of industrial illumination. In the same year requirements in regard to adequate lighting in connection with certain trades (lead working, vitreous enamelling, &c., and underground bakeries) were introduced, and an account of these was contributed to the *ILLUMINATING ENGINEER* by H.M. Chief Medical Inspector of Factories, Dr. T. M. Legge.²

In 1910 an important congress took place in Brussels, the Congrès International des Maladies Professionnelles,³ at which the writer was present as a delegate of the Illuminating Engineering Society and presented a paper on the Hygienic Aspects of Illumination. Industrial illumination received special notice at this Congress, special emphasis being placed on the need for adequate illumination in places where danger was apprehended. This point again received recognition in the Report of H.M. Chief Inspector of Factories, issued in this year (1910), in which the absence of any legislation on factory lighting was remarked on and the importance of good illumination pointed out "as a matter of safety (especially where dangerous processes are carried on); as bearing upon the health in many ways, directly and indirectly; and as a condition of efficient work."

Reference was also made to the exceptional importance of lighting in regard to underground premises.⁴

In 1911 the Report of the Departmental Committee appointed to inquire into Accidents in Factories and Workshops appeared. It contained a recommendation that "general statutory powers to require adequate lighting" should be conferred on the Home Office.⁵ A most important event during this year was undoubtedly the appointment by the Minister of the Interior in France of a State Committee on Illumination, charged with functions similar to those of the Committee in this country which has just reported.⁶ Yet another important step was the resolution to form an International Commission on Illumination, passed at the International Congress of Applied Electricity at Turin (September, 1911).⁷

In 1912 the Report of H.M. Chief Inspector of Factories again contained many references to lighting, including a special report by Mr. D. R. Wilson⁸ on Illumination. A report issued about this time by the National Association of Manufacturers in the United States,⁹ contained the result of inquiries among a large number of manufacturers with respect to the benefit derived from improved conditions of lighting. Subsequently another opportunity of bringing forward the claims of good industrial illumination was afforded

¹ *Illum. Eng.*, Vol. II., 1909, pp. 229, 319.

² *Illum. Eng.*, Vol. II., 1909, p. 373.

³ *Illum. Eng.*, Vol. III., 1910, p. 599.

⁴ *Illum. Eng.*, Vol. III., 1910, p. 493.

⁵ *Illum. Eng.*, Vol. IV., 1911, p. 401.

⁶ *Illum. Eng.*, Vol. IV., 1911, p. 455.

⁷ *Illum. Eng.*, Vol. IV., 1911, p. 616.

⁸ *Illum. Eng.*, Vol. V., 1912, pp. 380, 418.

⁹ *Illum. Eng.*, Vol. V., 1912, p. 384.

by the First International Congress for the Prevention of Industrial Accidents, held in Milan in May, 1912,¹⁰ at which the Home Office was officially represented and the writer again took part as a delegate of the Illuminating Engineering Society. At this Congress the connection between accidents and insufficient lighting was much discussed, and various aspects of industrial illumination were dealt with by a number of delegates from various countries. This Congress was the means of bringing the subject before the notice of the Governments of all the chief nations and shortly afterwards the Académie Royale de Médecine de Belgique approached the Belgian Government with a view to the appointment of a similar committee to that established in France.¹¹

On May 16th several questions were asked in the House of Commons by Dr. Arthur Lynch, M.P., drawing attention to the Committee formed by the French Government¹² and urging the desirability of arranging for an official inquiry into industrial illumination, and elicited the gratifying information from the Home Secretary that an expert Departmental Committee on this subject was to be appointed.

In 1913 the New York State Factory Commission were engaged on a Bill requiring "adequate and proper" lighting of factories,¹³ and at the National Gas Congress Exhibition held at Shepherd's Bush in the autumn a special section was given up to industrial illumination, and a variety of papers read emphasising the benefit of good illumination with a view to increased output and better quality of work. The Reports of H.M. Chief Inspector of Factories for this and the following year again contained much useful information on factory lighting, including a special report on the lighting of foundries. Early in the year 1913 came the announcement of the appointment by the Home Secretary of the Departmental Committee on Industrial Illumination.¹⁴

It will be seen, therefore, that the appointment of this Committee was not a sudden step, but a natural development as a result of several years of persistent propaganda of the illuminating engineering movements.

An examination of the contents of the Report reveals the same care and forethought. The Committee has taken pains to collect all the available information on industrial lighting and the compilation of data on the legislation of other countries will be studied with keen interest by those concerned in the management of factories. Fifty witnesses, including representatives of Trade Association, Factory Inspectors, Medical Officers and Physiologists, Lighting Experts, &c., have been examined. The importance of the subject and the need for investigations are now fully recognised, and to many people it will be a revelation to find how far the scientific study of lighting and illumination measurements have proceeded.

Besides taking evidence the Committee have visited a large number of factories, and about 4,000 measurements in 167 different workrooms have been made. Experiments on specific points were also conducted at the National Physical Laboratory.

This series of measurements was naturally of great value to the Committee in enabling them to judge as to the conditions actually existing in factories and the order of illumination which can conveniently be obtained.

The Committee draws a distinction between the illumination required for convenience and as a measure of safety, and the special illumination

¹⁰ *Illum. Eng.*, Vol. V., 1912, p. 335.

¹³ *Illum. Eng.*, Vol. V., 1912, p. 284.

¹¹ *Illum. Eng.*, Vol. VI., 1913, p. 17.

¹⁴ *Illum. Eng.*, Vol. VI., 1913, p. 107.

¹² *Illum. Eng.*, Vol. VI., 1913, p. 16.

required for certain industrial processes. It would obviously require a very long and careful investigation to decide this last point and it has therefore been reserved for future study. Meantime the figures given in the Report for the illumination at the point of work in those industries so far examined will be found of great interest by those concerned with factory lighting.

As a result of their investigations the Committee suggest that there should be a general requirement of adequate lighting in the Factory Act and they also recommend certain minimum values for the general illumination, which are necessary in the interests of safety and general convenience. In this connection the utility of the complete series of measurements summarised in the Report is very evident. A study of the "frequency of occurrence" curve makes it clear that the values suggested are well below what may reasonably be expected in a modern well-lighted factory. There should, therefore, be no hardship in these recommendations, and their general effect would merely be to bring into line with modern practice those factories which are poorly lighted by antiquated and imperfect methods. The moderation of the proposals will, we feel sure, commend them to the manufacturers. Both among employers and employees there is a widespread recognition, that defective lighting, besides being a possible source of injury to health and a cause of accidents, also tends to restriction of output and spoilage of work. It handicaps the operator in carrying on his daily task and adds to the strain of occupation, especially when he is engaged on highly-skilled and delicate operations. Managers of factories, it will be found, are only too anxious to receive guidance in these matters and we feel sure that they will find in the Report many serviceable and practical suggestions.

We would like to draw attention to the very practical way in which the Report is drawn up. The attempt has been made to express technical matters in a simple and intelligible form. In the past there has been some vagueness as to what was meant by "inadequate" lighting, and the careful explanation of the various defects which are included in this expression will help to make this matter clear. An enterprising step is the issue of a popular abstract in the form of a memorandum accompanying the Report, explaining the general objects which the Committee have in view.¹⁵ It is hoped that this will be of considerable assistance to the press and to the general public.

This Report marks a new departure in the study of factory lighting. It is a piece of work quite different from anything published in other countries, and in this particular matter we may claim to have taken a step in advance of the rest of the world. The effect of the Report should be to place industrial illumination in this country on a higher plane and to strengthen the position of those in other countries who are working for the same ends.

At the present time the public mind is awakening to the value of science. We venture to think that we have here an excellent example of the modern application of science to practical affairs. The lighting industry is under a debt of gratitude to the Members and the Secretaries of this Committee, and the Report should be generally received as a most useful and timely production of which we have every reason to be proud.

LEON GASTER.

¹⁵ An abstract of this Memorandum will be found in the following two pages

MEMORANDUM ON THE FIRST REPORT OF THE DEPARTMENTAL COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.

(Slightly abbreviated).

THE development of industrial operations and the introduction of many new methods of illumination during the last 10 years have served to emphasise the need for statutory requirements relating to the lighting of workshops and factories, similar to those which already exist in regard to heating and ventilation.

The present Committee was appointed—

“to enquire and report as to the conditions necessary for the adequate and suitable lighting (natural and artificial) of factories and workshops, having regard to the nature of the work carried on, the protection of the eyesight of the persons employed, and the various forms of illumination.”

EXISTING LEGISLATION.

For the United Kingdom no general provisions in regard to lighting (analogous to those regarding heating and ventilation) occur in the Factory Acts, although adequate lighting in general terms is included among the conditions to be satisfied in underground bakehouses, and is required in certain dangerous trades.

On the other hand, the codes of all the chief European countries, the United States, and India contain provisions requiring adequate lighting in factories.

NATURE OF ENQUIRY.

The appointment of the Committee in regard to Industrial Lighting thus marks an entirely new departure in this country.

In view of the wide ground covered by the terms of reference it was considered advisable to limit the enquiry in the first instance as far as possible to the engineering, textile, and clothing trades. Evidence was received from 50 witnesses, including H.M. Inspectors of Factories and representatives of various trade associations and scientific and technical societies.

The members of the Committee also paid a series of visits to various industrial centres, 85 works being visited. In connection with these visits about 4,000 measurements of illumination were made in 163 rooms in 57 factories.

Certain experiments bearing on the standards of illumination required for various purposes were also carried out at the National Physical Laboratory.

EFFECTS OF BAD LIGHTING.

The enquiry showed that there has been a great advance in methods of illumination, but various defects were met with, and the Committee endeavoured to obtain particulars of the effect of unsatisfactory lighting.

A statistical enquiry into the number of accidents during each month throughout the year points to the conclusion that inadequate lighting is a contributory cause of accidents. This is confirmed by the evidence of witnesses, and by the statements of the Accident Offices' Association.

Complaints of eye strain, headache, &c., attributed to insufficient lighting are common, and while an exhaustive medical enquiry would be necessary to establish the connection between these defects and inadequate lighting, there is a general impression that unsatisfactory lighting is, in various ways, prejudicial to health. It is also recognised that insufficient light adds to the difficulty of the proper supervision of work, and of the maintenance of cleanliness and sanitary conditions generally.

Witnesses gave specific instances of the effect of improved lighting in increasing the output and improving the quality of work turned out.

RECOMMENDATIONS.

From the evidence taken it is apparent that there is a general consensus of opinion as to the economic and hygienic advantages of adequate and suitable lighting. That this opinion is based on experience is shown by the great improvement in lighting which has taken place during recent years, and is still continuing, and in modern factories good lighting is now regarded as one of the most important factors contributing to industrial efficiency. On the other hand many employers have lagged behind in the general advance. This refers especially to old factories, and it is obvious that any requirement which would tend to bring such places up to the level of more progressive firms would be beneficial, not only to the operative by improving his working conditions, but also to the employer himself by increasing his output and by improving the quality of work. Light is a cheap commodity and little or no hardship should result from such a requirement, if gradually and sympathetically enforced.

The Committee therefore recommend that there should be a statutory provision :—

(a) Requiring adequate and suitable lighting in general terms in every part of a factory or workshop, and (b) Giving power to the Secretary of State to make Orders defining adequate and suitable illumination for factories and workshops or for any parts thereof or for any processes carried on therein.

It is further necessary to define more precisely the term “adequate lighting.” In order to justify this description, the illumination should comply with the following requirements :—

(a) Adequacy. (b) A reasonable degree of constancy and uniformity of illumination over the necessary area of work. (c) The placing or shading of lamps so that the light from them does not fall directly in the eyes of an operator when engaged on his work, or when looking horizontally across the workroom. (d) The placing of lights so as to avoid the casting of extraneous shadows on the work.

The next question is the desirability of specifying the amount of illumination implied in the terms “adequate and suitable.” Owing to the great progress that has recently been made in the appliances for measuring illumination (the nature of which is explained in the Report), it is now practicable to specify numerical values in a manner that would hardly have been possible some years ago.

The Committee propose the following minimum values of illumination (measured at floor level) as being desirable from the standpoint of general convenience and safety :—

	Ft.-candle.
In the working areas of factories generally	0.25
the working areas of foundries	0.4
all parts of factories, over which people are liable to pass ..	0.1
open places where people are employed, dangerous parts of	
regular roads and approaches	0.05

Provision is also made for exemption in individual cases ; ship building yards are to receive separate consideration.

These values are suggested without prejudice to the special illumination required for the carrying out of the work, which naturally varies greatly according to the nature of the operations. At present the Committee are not prepared to recommend standards of illumination for these purposes, which require further investigation.

In conclusion the Committee point out that the minimum values prescribed are considerably lower than those proposed by many witnesses and are also lower than those found to exist in the majority of factories visited. In many cases manufacturers would naturally prefer to provide a substantially higher value than that indicated. The intention has been to propose values which can be adopted as a practical legal minimum without causing hardship, and would serve the purpose of raising the level of illumination in those factories which are behind modern practice in this respect.

Adequate artificial lighting is an important matter in the utilisation of factories for night work. The information contained in the report should therefore be of special interest at the present moment, when many factories are working overtime, and preparations are being made for the period of the year when artificial lighting is mainly required.

ABSTRACT OF THE FIRST REPORT OF THE DEPARTMENTAL COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.*

Constitution and Terms of Reference.

THE Committee was appointed by the Home Secretary in 1913, and originally consisted of the following:—

Dr. R. T. Glazebrook, C.B., D.Sc., F.R.S., Director of the National Physical Laboratory.

Mr. L. Gaster.

Prof. Francis Gotch, D.Sc., F.R.S.

Mr. J. Herbert Parsons, M.B., D.Sc., F.R.S.

Mr. W. C. D. Whetham, F.R.S.

Sir Arthur Whitelegge, K.C.B., Chief Inspector of Factories.

Dr. Glazebrook was appointed Chairman of the Committee and Mr. D. R. Wilson, one of H.M. Inspectors of Factories, and Mr. C. C. Paterson, of the National Physical Laboratory, were appointed to be Secretaries of the Committee. Owing to the death of Professor Francis Gotch at an early stage of the proceedings, Professor C. S. Sherrington was appointed to fill the vacancy on May 29th.

The terms of reference of the Committee are stated as follows:—"To enquire and report as to the conditions necessary for the adequate and suitable lighting (natural and artificial) of factories and workshops, having regard to the nature of the work carried on, the protection of

the eyesight of the persons employed, and the various forms of illumination."

Methods of Investigation.

The methods of investigation may be divided roughly into two sections—Evidence of Witnesses and Experimental Work. In the course of the enquiry the Committee has held 38 meetings and received evidence from about 50 witnesses. The latter include:—Official representatives (Inspectors of Factories, Medical Officers of Health, Factory Certifying Surgeons, etc.); Professional, Technical and Scientific Witnesses (Lighting Experts, Representatives of Professional and Scientific Societies, Architects, Surveyors, and Medical Experts); Representatives of Trade Associations (both Employers and Operatives).

Witnesses were nominated by the following societies:—

The Illuminating Engineering Society,
The Institution of Electrical Engineers,
The Institution of Gas Engineers,
The Ophthalmological Society of the United Kingdom,
The Royal Society of Medicine,
The Royal College of Surgeons,
The Royal Institute of British Architects,
The Surveyors' Institution.

* Blue Book (Cd. 8000), Vol. I. Report and Appendices, Vol. II. Evidence. Issued by His Majesty's Stationery Office by Eyre & Spottiswoode, Ltd., East Harding Street, E.C. To be purchased either directly or through any bookseller, from Messrs. Wyman & Sons, Ltd. (London and Cardiff), H.M. Stationery Office (Edinburgh), E. Ponsonby, Ltd. (Dublin), or from the Agencies in the British Colonies and Dependencies, the United States of America and other foreign countries, of T. Fisher Unwin (London, W.C.).

At the outset of the enquiry it was decided to obtain practical data regarding the natural and artificial lighting of factories at the present time. In view of the wide ground covered by the terms of reference it was, however, decided to limit the enquiry to the textile, engineering, and clothing trades, certain general considerations applicable to all trades being taken into consideration. As a

rule, measurements were made previous to the visits of the Committee so that definite facts should be available at the time the illumination of the factory was inspected.

In the course of the investigation about 4,000 measurements in 163 rooms of 57 representative factories and workshops were made by Mr. J. W. T. Walsh of the National Physical Laboratory and Mr. G. F. Sedgwick, H.M. Inspector's Assistant. All these data are published in an Appendix to the Report, together with particulars as to the size of rooms and windows, and the number and nature of the light sources installed.

In addition to the above experimental work, a number of special observations were carried out at the National Physical Laboratory, a room being prepared in which the conditions of illumination could be changed at will. These observations included tests of workpeople using various materials, the object being to ascertain the intensity of illumination preferred for various processes, and the effect of altering the colour of the material used in the clothing industry.

Explanation of Technical Terms.

The Report next passes on to explain various terms used in referring to illumination.* After defining the "foot-candle" the Report points out how the quantity of light reflected from a surface depends on its colour and why, therefore, dark materials in general require a higher illumination than those which are light in hue.

In connection with glare a distinction is drawn between the effect of bright sources in the direct line of sight and those seen obliquely "out of the tail of the eye." Attention is also drawn to the glare experienced when light is reflected directly into the eyes from objects having a highly polished surface.

A brief reference is also made to the "daylight factor" (*i.e.*, the relation between the natural illumination at a

point inside a room and the total unrestricted illumination out of doors). This quantity should be approximately constant for a given interior and depends chiefly on the window-area which is effective in admitting daylight to the point in question. The term is fully explained in an Appendix.

Existing Requirements as to Lighting.

For the United Kingdom no general provisions in respect to lighting (analogous to those regarding temperature and ventilation) occur in the Factory Acts. The only reference to the subject is found in the Factory Act of 1901, Section (4), which specifies adequate lighting amongst the conditions as to which a local authority must be satisfied before an underground bakehouse is certified as suitable for use.

Under Section 79 of the Act of 1901 the Secretary of State has power to make regulations for certain trades certified by him to be dangerous. These regulations, after conforming to a certain procedure, eventually attain the force of statutory enactments. Some 20 codes of regulations exist, and of those five (relating to Docks, use of Locomotives, etc., on premises under the Factory Acts, Vitreous Enamelling of Metal and Glass, Generation of Electrical Energy and Manufacture and Decoration of Pottery), contain provisions requiring adequate lighting in general terms for certain processes. Finally, adequate lighting is required in two Special Orders made by the Secretary of State relating to Fruit Preserving and Sanitary Accommodation.

In order to obtain information as to the position in foreign countries, inquiry was made through the Foreign Office as to the requirements in force in Austria, Belgium, Denmark, France, Germany, Holland, Italy, Norway, Sweden and the United States of America. The replies received are summarised in an Appendix. Adequate lighting in general terms is required in the codes of all the European countries mentioned, and in those of most of the United States, either by legislation or statutory regulations. For local lighting in certain trades definite standards are prescribed in Holland only, whilst a provision against excessive glare is found in the Belgian code.

* In view of the novel nature of the subject this is a wise step and should help to make the Report readily intelligible to those manufacturers as are not very familiar with such expressions as "intensity of illumination" and "surface brightness."

A provision requiring giving the Inspector power to require adequate lighting in factories exists in the Indian Factory Act for 1911. It also appears that a definite standard for the general lighting of factories is now in force in New South Wales.

Reference is also made in the Report to the London Building Act of 1894 and the building regulations of many provincial authorities, limiting the amount of wall space in laterally lighted rooms to one-half the total wall space. According to some witnesses this unnecessarily interferes with the lighting of the building. Similarly, the regulations prescribing whitewashing of roof windows of cotton cloth factories during the summer months demand careful consideration in relation to certain classes of work with dark materials, for which all available illumination is needed on dark days.

There are also regulations issued by the Board of Education with regard to school buildings, requiring adequate window space, suitably-placed windows, light walls, etc., and there are similar regulations in force in most of the foreign countries of which enquiry has been made. The construction of workhouses and other buildings under the control of the Local Government Board is subject to special instructions issued by the Board. Finally the Housing, Town Planning, etc., Act of 1909 empowers local authorities to make regulations for underground rooms habitually used as sleeping places.

Present Conditions of Lighting in Factories.

Natural Lighting.

The natural lighting of buildings may be derived either from the roof (roof or top lighting) or from side windows (lateral lighting) or from both combined.

Roof lighting is obviously only available in single storied buildings or in the top floor of a block. A common arrangement in weaving sheds is the "saw-tooth" type of roof. With a good system of roof lighting the illumination is very uniform and may attain from 2 to 10 per cent. of the outside unobstructed illumination. The large extent of surface sometimes makes it difficult to maintain an equable temperature; whitewashing the glass to

keep out the direct rays of the sun is largely practised in summer, while extra means of heating are provided during the winter.

In most trades, where the working plane is horizontal, lateral lighting is inferior to roof lighting. In modern factories dependent mainly on lateral lighting a large part of the wall surface (sometimes as much as 60 per cent.) may be occupied by windows but even so there is a limit to the depth of room—beyond which the illumination falls below what is considered an adequate value. The illumination near the windows may be well lighted, while the most remote parts of the room may require permanent artificial illumination.

Artificial Lighting.

The conditions of artificial lighting vary so widely that only a very general statement can be made. The Committee express the view that the artificial lighting of factories has made great strides during recent years. Generally speaking, in modern factories good illumination is provided where it is required for the actual purposes of manufacture, though complaints have been received of inadequate lighting in some trades where fine work (tailoring, sewing, lace making, &c.) is carried on. Insufficient illumination is more commonly met with in the general lighting of premises, or in the lighting of gangways, stairways, &c.; in this respect the conditions in many factories are capable of much improvement. Instances of glare and inconvenient shadows are also mentioned.

Causes of Unsatisfactory Illumination.

Natural Lighting.

Among the causes of unsatisfactory natural lighting the Committee mention:

- (1) Old and unsuitable buildings.
- (2) Obstruction of light.
- (3) Dirty windows.
- (4) Dirty walls and ceilings.

There is a great contrast between the conditions of illumination in old converted buildings, originally intended for dwelling houses, &c., and those met with in modern factories, which are usually excellently lighted. Underground work-rooms are frequently poorly lighted and

in some instances require the continuous use of artificial illumination. At present there appears to be no legislation with regard to the use of such premises for industrial purposes except in the case of underground bakeries (referred to on p. 372.)

Obstruction is usually caused by adjacent buildings, and may be mitigated by whitewashing the obstructing surface, or the adoption of special mirrors or glass. The temporary storage of materials inside the factory and the presence of high machines also obstruct the light in some instances.

Dirty windows are a frequent cause of insufficient lighting, and periodical cleaning is desirable. Similarly dirty walls and ceiling cause a loss in reflected light. The Committee lay stress on the value of light surroundings as an inexpensive means of improving the illumination and furnishing a useful background to dark objects.

At present there are not available complete statistics showing the effect of habitual use of artificial light and the exclusion of daylight on health. There is, however, a general consensus of opinion among witnesses of all classes that conditions involving the continuous use of artificial light are unnatural and entail a greater strain on the workers.

The Report makes the following suggestions for promoting access of daylight, of which full use should be made in over-shadowed rooms :—

(1) The windows should be of adequate size and extend as near the ceiling as possible.

(2) They should be kept clean and free from unnecessary obstruction within.

(3) Vertical light can be deflected into the room by means of reflectors or prismatic glassware.

(4) It may be possible to whiten the surface of an external wall or building which obstructs the light.

(5) The inside walls and ceiling should be white or nearly white.

(6) The positions of the permanent working points should be so adjusted in relation to the windows and to internal obstructions of whatever kind as to secure as far as practicable adequate daylight for each.

It is pointed out that improved daylight facilities, by restricting the period during

which artificial light is needed, constitute an economy. The question of a standard for daylight is a difficult one, which is to receive further investigation. Attention is, however, called to the use of the "daylight factor" which may be of service in this direction.

Artificial Lighting.

Among the causes of unsatisfactory illumination are mentioned :—

(1) The provision of too few or too weak lights.

(2) Antiquated Methods of Lighting.

(3) Inadequate supply.

(4) Neglect of Upkeep.

(5) Inside Obstruction.

(6) Shadows and improper placing of lights.

Reference is made to the continued use of flat flame gas burners in some factories where modern methods of incandescent gas lighting might be more fitly used. Complaints have also been received of inadequate illumination caused by diminished pressure from gas mains during the period of maximum supply, and by the installation of a dynamo or engine of insufficient power in cases where electric energy is generated on the premises.

Systematic attention to the lights is desirable to avoid loss of light through accumulation of dust. Obstruction may be caused by travelling cranes and shadows are apt to be thrown on the work if the positions of lamps are not carefully selected—as for example in machine sewing and boot-making.

The Effects of Unsatisfactory Lighting.

Among the effects of artificial lighting may be mentioned :—

(1) Accidents.

(2) Damage to Eyesight and Health.

(3) Insanitary Conditions.

(4) Diminished output of work.

(5) Lack of Discipline.

The connection between lighting and accidents has been studied by means of a special return of the accidents during 1913 and part of 1914. It appears that accidents due to "persons falling" (a cause which would seem to be specially dependent on lighting conditions) are more numerous during the winter months when

artificial lighting is mainly used. The results indicate that for most industries the probable accident rate per hour is far higher for artificial than for natural lighting, in some cases to the extent of 40 per cent. It is pointed out that, strictly speaking, these statistics only allow of a comparison between natural and artificial lighting and not between good and bad lighting of the same kind. But inasmuch as natural lighting may be considered superior to artificial lighting, so far at any rate as regards liability to accident, it may be inferred that the same relationship would hold good between any methods of good and bad lighting.

Further confirmation of the greater risk of accident during the night was given in the evidence of several witnesses. Thus it was pointed out that the number of accidents occurring in shipbuilding yards at night is quite out of all proportion to the small number of men employed. Instances of accidents due to bad lighting conditions were also given for foundries, iron and steel works, lace factories and cotton mills.

An inquiry was also addressed to the Accidents Offices Association, which embraces most of the Insurance Companies interested in the Workmen's Compensation Act. In the reply of the Association it was stated that:—

(A) "The rates of premium charged by its members are based upon the assumption that the lighting is normal; that if, upon survey, this is not found to be so, the insuring Company would specify its requirements or deal with the case by rating."

(B) "The effect of deficient or bad lighting upon a risk is distinctly prejudicial in varying degrees from the accident point of view."

As regards the question of damage to eyesight and health the Committee remark that complaints as to eyestrain and headache attributed to artificial light are common. Numerous references are also made to glare from light sources, and to the prevalence of the use of spectacles among workers in certain trades (drawing in and twisting embroidery, tailoring, &c.). Without an exhaustive medical examination of the eyes of large numbers of workers it is impossible to draw definite conclusions on this point. It is, however,

well known that serious injury accrues from exposure to very intense light, such as welding, glass bottle making, &c., and many expressions of opinion have been received to the effect that insufficient light and excess of light, especially when accompanied by glaring sources in the field of vision, are responsible for injury to the eyes.

The absence of sufficient light is detrimental in that dirt is allowed to escape notice, and this aspect is recognised in regard to fruit-preserving and underground bakehouses, in which adequate illumination is required by law.

The effect of improved lighting in improving the quality and increasing the output of work has been noted by many witnesses. In one instance the output was diminished 12—20 per cent. during the period of artificial lighting, and in another the earnings of the workers increased 11.4 per cent. after the installation of a better system of lighting. Confirmatory evidence has been published in the United States of America. Good lighting is also essential for the proper supervision of work and the detection of idling and irregularities.

Recommendations.

From the evidence submitted the Committee find that there is a general consensus of opinion as to the economic and hygienic advantages of adequate and suitable lighting. That this opinion is based on experience is shown by the great improvement in industrial lighting which has taken place in recent years and is still continuing. In the designing of modern factories good lighting (both natural and artificial) is now regarded as one of the most important factors contributing to industrial efficiency. On the other hand many employers have lagged behind the general advance. This applies especially to old factories designed before the importance of illumination was generally recognised, and to small workshops, of which the occupiers perhaps hesitate to expend the capital necessary for improvement.

It is obvious that any requirement which would tend to bring such places up to the level of the more progressive firms would be beneficial, not only to the

operative by improving his working conditions, but also to the employer himself by increasing his output. Light is a cheap commodity and little or no hardship should result from such a requirement, if gradually and sympathetically enforced.

It has been remarked that there is evidence of a relationship between accident risk and adequacy of lighting, and although complaints as to damage to eyesight resulting from bad lighting are general in character, and specific instances of injury are difficult to substantiate, there is evidence of the existence of minor ailments and general impairment of efficiency which must eventually react on the health of the workers.

The Committee also point out that the degree of comfort in the working conditions is doubtless largely determined by the adequacy of the lighting. The visits paid to factories have enabled them to realise the contrast between the depressing effect of dark surroundings and the cheerfulness of a brightly illuminated workroom; and the vast difference in the working lives of the operatives that must result from continual employment under the two conditions.

Finally it is pointed out that the necessity of adequate lighting in factories and workshops has long been recognised abroad, and the industrial codes of all the principal countries contain provisions requiring it in general terms.

The Committee therefore recommend that :—

1. There should be a statutory provision—

(a) **requiring adequate and suitable lighting in general terms in every part of a factory or workshop, and**

(b) **giving power to the Secretary of the State to make Orders defining adequate and suitable illumination for factories and workshops or for any parts thereof or for any process carried on therein.**

It is desirable to define as closely as possible what is meant by “adequate and suitable lighting.” The lighting is regarded as adequate and suitable, provided that :—

(a) it is sufficient for the proper carrying out of the work both as regards quality and output, and

(b) there are no lighting conditions, prejudicial to the health, comfort and safety of the workers,

In order to satisfy these conditions the lighting should comply with the four requirements previously specified, namely :—

(1) Adequacy.

(2) A reasonable degree of constancy and uniformity of illumination over the necessary area of work.

(3) The placing or shading of lamps so that the light from them does not fall directly on the eyes of an operator when engaged on his work, or when looking horizontally across the workroom.

(4) The placing of lights so as to avoid the casting of extraneous shadows on the work.

The Committee are of opinion that the general statutory requirement of “adequate and suitable lighting” should include the observance of the last three conditions, in addition to the provision of a sufficient amount of illumination, and that power should be given to secure compliance with them in cases where their neglect clearly renders the lighting “inadequate and unsuitable” in any of the particulars given above. Special emphasis may be placed upon the avoidance of glare, of excessive contrast, and flickering lights.

It is pointed out that standards of adequacy in regard to temperature and ventilation of factories already exist. Similarly, in connection with lighting, standards could be based on the “foot-candle.” The Committee point out, however, that although intensity of light at the working plane is a most important factor of adequacy and suitability, it is not the only one by any means, and special consideration must also be given to the other factors mentioned above.

A distinction must also be drawn between the illumination required for the purposes of carrying out work and the illumination necessary from the standpoint of general convenience and safety. Whatever be the light required for the work it is necessary that the working area should be illuminated sufficiently for obstacles, dirt and waste, to be clearly visible; whilst in all industries, particularly those in which the work involves danger, it is essential that the general illumination should be sufficient to avoid risk of accidents. Ample illumination for the requirements of the work itself

must be provided beyond the minimum general illumination needed for these purposes.

In the appendix to the report particulars of the illumination existing in a few select trades, namely, clothing, engineering, and textile industries, are summarised, and form, it is believed, a unique analysis of existing industrial lighting conditions. It is, however, obvious that the amount of illumination required for carrying out work will depend on many different factors. In cotton weaving, for example, the optimum illumination varies with the colour of the yarn, the fineness of the yarn, the style of the weave, and other circumstances, and a single standard prescribed to cover cotton weaving generally would err, in some instances in the direction of prodigality, in others of insufficiency.

For the moment the Committee think it is desirable to reserve any expression of opinion as to the minimum amount of illumination for special purposes. They consider, however, that standards may reasonably be proposed regarding the general illumination. For this purpose, what is aimed at is a value which may reasonably be enforced as a statutory minimum, rather than what is now the average practice. From the data relating to the illumination existing in factories, the "mid-point" (or point above and below which an equal number of observations lie) is 0.45 ft. candle. As a statutory minimum value, the Committee recommend that:—

2. Over the "working areas" of workrooms the illumination measured on a horizontal plane at floor level shall not be less than 0.25 foot-candle, without prejudice to the illumination required for the work itself.

Attention has been called to the special difficulties which would be caused if a ship under construction or repair were considered for the purpose of this regulation as part of the working area of a factory, and it is, therefore, proposed to reserve for future consideration the question of the illumination to be provided in ships. Special provision will also be necessary for certain workrooms, where the prescribed illumination would interfere with the proper carrying out of some process, such as the manufacture of photographic materials.

Iron Foundries.

The question of iron foundries also requires special consideration. It appears to be that the illumination in foundries is at present below the average of other workrooms; although the dark surroundings indicate the desirability of special good lighting in such work, and the Committee are of opinion that a minimum illumination of 0.25 ft. candle is not sufficient for safety. They accordingly recommend that:—

3. In all parts of iron foundries in which work is carried on or over which any person is ordinarily liable to pass, the illumination measured on a horizontal plane at floor level shall not be less than 0.4 foot-candle.

Passages, Stairways, Lobbies, &c.

On the other hands for the lighting of passages, stairways, lobbies, &c., a lower illumination should suffice than in the case of workrooms, since obstacles are usually absent, and the eye is not subjected to the same degree of contrast. Nevertheless many instances of defective lighting were noticed and complaints were received from witnesses on this point. The experience gained from visits to factories indicates the desirability of adopting for these spaces a standard of not less than 0.1 ft. candle. Instances requiring special latitude (such as long passages free from all abrupt changes of level and adequately lighted by the "beacon" system) are dealt with separately under recommendation number 6. It is accordingly recommended that:—

4. In all parts of factories and workshops (not included under recommendation 2) over which persons employed are liable to pass, the illumination measured on the horizontal plane at floor level shall not be less than 0.1 foot-candle.

Open Yards and Approaches.

Here the object of the lighting is to enable a person to see sufficiently well not to stray from the path, and may be compared with that of streets. For any locality where persons are employed at night and for a path or road to which it is necessary to keep, in order to avoid danger (such as an approach leading through a yard containing obstacles), the Committee are of opinion that a minimum illumination equivalent to that of a fairly well-lighted side street (0.05 foot-candle) will be sufficient.

Approaches over clear ground (free from projecting rails or other obstacles and from steps or other abrupt changes of level) where momentary straying from the path involves no risk, and also fenced-in roads, can be adequately lighted by the "beacon" system, namely the spacing of light sources along the direction of the path at such long intervals that they serve as beacons or guides rather than means of illumination. These would not be "dangerous parts" in the intended sense of the next paragraph.

In docks, both places of employment and approaches are already subject to a requirement for adequate lighting in general terms (Regulations for Docks, Reg. 3). It is recommended in accordance with this precedent, that :—

5. In all open places in which persons are employed during the period between one hour after sunset and one hour before sunrise, and in any dangerous parts of the regular road or way over a yard or other space forming the approach to any place of work, the illumination on a horizontal plane at ground level shall be not less than 0.05 foot-candle.

The case of ship-building yards require special consideration, and is reserved for a future report.

In order to meet exceptional circumstances in which the standards proposed in recommendations 2, 3, 4 and 5 might cause hardship, it is recommended that :—

6. There shall be power for the Department to allow exemption in individual cases.

Finally the Committee emphasise the importance of keeping window screens clean and making the following general provisions :—

7. All external windows of every work-room shall be kept clean, on both the inner and outer surfaces,

but in order to meet exceptional cases (as below), there should be power to substitute for the above a definite and binding scheme for cleaning the windows at reasonable fixed intervals, where for example :—

(A) the windows, or some of them (*e.g.*, roof windows) are not readily accessible ; or

(B) The total surface of external windows is exceptionally large in relation to the floor space ; or

(C) The conditions of work are such that compliance with the ordinary requirement

is, in consequence of the nature of the work, impossible.

Conclusion.

In concluding their report the Committee make the following remarks which we reproduce *in extenso* :—

"In submitting these recommendations we realise that the standards proposed by us appear to be lower than the values put forward by various lighting experts who have given evidence before us. Some of the latter referred to the general illumination at the working level, where the values are naturally higher than at the floor level, and in any case we have felt that they were intended as an indication of ideal conditions, whereas it has been our object to suggest numerical values that can be adopted as a practical legal minimum without causing hardships. It must be remembered that in view of the diversity of illumination which always exists, whatever the system of lighting, any minimum value will usually connote a very much higher maximum and average, so that with a given minimum the efficiency of the illumination depends to a large extent on this diversity. A workroom, for instance, in which the illumination is uniform and has the value of only 0.25 foot-candle, may be regarded in most cases as very inadequately lighted. We desire, therefore, to point out that none of the recommendations made by us is intended to supersede the requirement of general adequacy and suitability, which, as already explained, depend on several factors in addition to the amount of illumination.

The evidence before us from witnesses and our own observations do not justify us in drawing any distinctions in the present recommendations between direct, indirect, or semi-indirect systems of lighting, or between systems which differ in the colour-composition of the light. We suggest, therefore, that the standards proposed should be adopted irrespective of the type of lighting. Similarly, the evidence does not justify us in discriminating between natural and artificial lighting, and in the recommendations submitted by us, the standards are intended to apply equally to both, that is to say, when the natural illumination falls below the limits proposed, it must be supplemented or replaced by artificial illumination.

The more specific recommendations of this Report may be said, broadly, to deal with the general lighting of factories and

workshops; in other words, they have for their object the maintenance in all workplaces of certain standards of illumination primarily intended to ensure the personal safety of workpeople moving about the premises. In the great majority of factories, however, the standards of general lighting suggested here would be inadequate for the actual machines and work benches where the various manufacturing processes are carried on, and local lighting in addition is generally essential. As already mentioned, we are not prepared at present to suggest values for the minimum illuminations which may be regarded as adequate for special processes.

It was originally our intention to supplement the data already collected for

the clothing, engineering, and textile trades, and to extend our inquiries on similar lines so as to include other industries. In view, however, of the present economic disorganisation we think it desirable to submit an interim report of the work already done, and to await settled conditions before prosecuting the inquiry.

The data given in several of the appendices will help those engaged in designing new factories and in examining the adequacy of lighting in existing buildings. At present there are few collated data of this character available, and the desire not to withhold them longer from publication is a further reason for the submission of a preliminary Report at this stage."

(Signed) R. T. GLAZEBROOK (*Chairman*), L. GASTER, J. HERBERT PARSONS,
C. S. SHERRINGTON, W. C. D. WHETHAM, ARTHUR WHITELEGGE.
D. R. WILSON, C. C. PATERSON, *Joint Secretaries*.

INFORMATION IN APPENDICES.

The Report itself occupies 19 pages, but it is followed by a valuable series of 16 appendices, filling 67 pages in all. We can only give a very general summary of the contents of these appendices, but they well deserve study.

LIST OF WITNESSES.

The complete list of the witnesses examined, 50 in number, is given as follows:—

(1) OFFICIAL.

1. G. Bellhouse, H.M. Superintending Inspector of Factories.
2. W. Williams, H.M. Superintending Inspector of Factories.
3. J. A. Hine, H.M. Superintending Inspector of Factories.
4. Miss R. E. Squire, H.M. Senior Lady Inspector of Factories.
5. H. J. Wilson, H.M. Inspector of Factories.
6. H. Kenwood, Medical Officer of Health for Stoke Newington.
7. T. W. Heywood, Certifying Surgeon, Darwen.

(2) PROFESSIONAL, TECHNICAL AND SCIENTIFIC.

(a) Illuminating Engineering Experts.

8. J. G. Clark and How, Gas Light & Coke Co.
9. H. C. Wheat, British Thomson Houston Co., Ltd.
10. Albert Stokes, South Metropolitan Gas Co.
11. A. P. Trotter, Elec. Adviser, Board of Trade.
12. T. E. Ritchie, The Union Electric Co., Ltd.
13. A. J. Whyte, and J. Augus, Messrs. Jas. Keith and Blackman, Ltd.

(b) Representatives of Professional and Scientific Societies.

14. Haydn T. Harrison, Illuminating Engineering Society.
15. V. H. Mackinney, Illuminating Engineering Society.
16. J. S. Dow, Illuminating Engineering Society.
17. A. Siemens, Institution of Electrical Engineers.
18. Franklin Thorp, Institution of Gas Engineers.

(c) Architects and Surveyors.

19. P. J. Waldram, London.
20. W. E. Potts, Manchester.
21. J. B. Cass, Bolton.
22. Lewis Solomon, London.
23. Segar Owen, Warrington.
24. H. Hartley, Liverpool.

(d) Medical.

25. F. W. Edridge Green, Ophthalmic Surgeon.
26. W. McDougall, Physiologist.
27. F. R. Cross, Ophthalmic Surgeon.

(3) REPRESENTATIVES OF TRADE ASSOCIATION.

(a) Employers.

28. John Taylor, Cotton Spinners and Manufacturers.
29. H. L. Symonds, London Chamber of Commerce.
30. John Carr, London Chamber of Commerce.
31. S. A. Russell, London Chamber of Commerce.
32. W. A. Hughes, Fine Cloth Manufacturers' Association.
33. Robert King, National Light Iron-founders' Association.

34. John Allen, National Federation of Merchant Tailors.
35. John Dewrance, Engineering Employers' Federation.
36. Fred Skull, High Wycombe & District Chamber of Commerce.
37. William Eccles, High Wycombe & District Chamber of Commerce.
38. Thomas Harrison Thorpe, Derby Chamber of Commerce.

(b) *Operatives.*

39. R. Trebateoff and A. Hillman, Jewish Tailors' etc., Trade Union.
40. Thomas Shaw, Amalgamated Weavers' Association.
41. W. C. Robinson, Beamers', Twusters' and Drawers' Association.
42. A. Hutchinson, National Union of Stove Grate Workers.
43. R. Girvan, Scottish Operative Tailors' Association.
44. A. Smalley, Operative Bleachers' etc., Association.
45. F. Lockyear, Ironfounders' Society.
46. C. Wardle, Operative Lacemakers' Society.
47. W. Hartshorn, National Hosiery Federation.

(4) MISCELLANEOUS.

- 48-50. Three Working Tailors.

STATISTICS FOR THE CHIEF INDUSTRIES.

In Appendix II. we have a complete list of the textile, engineering, clothing, and miscellaneous factories visited.

Following this we have a summary of the number of people employed in the various industries of the country. It is interesting to notice that the total number of persons employed in the textile industries alone is *one million*, while in miscellaneous industries (factories and workshops in which more than fifty thousand persons are employed), we find that the total number of persons employed exceeds four millions. The highest aggregate in this section falls under the heading of engineering, which employs approximately five million thousand hands. These figures will give an idea of the importance to the community of any matter affecting the welfare of employees as a whole. We see by these figures that, even excluding the smaller factories throughout the country, five million people are directly concerned.

GENERAL INFORMATION ON FACTORY LIGHTING.

In Appendix III. there is reproduced a circular letter addressed to 77 Trade Associations throughout the country, with a view to obtaining information of special interest to the Committee. As an

indication of the kind of evidence required the letter suggests the following points :—

(a) The possibility of defining and establishing a standard or standards of adequate illumination suitable for the various operations and processes in the trade represented by your Association.

(b) The classification of processes in relation to the illumination required.

(c) The enumeration of the various processes in which specially good illumination is desirable, and information as to means of securing it.

(d) Examples of processes presenting special difficulties in respect of efficient lighting, owing to the relative positions of the work and of the light sources, or for other reasons.

(e) Particulars of the methods of illumination in general use, with details of special systems which have been adopted for special processes.

(f) The relative merits of daylight and artificial illumination, and the extent to which the latter is used, depending on the usual period of employment in the industry represented by your Association.

In addition to the circular letter referred to above, H.M. Inspectors were requested to forward information on such points as the following :—

(a) Processes requiring exceptionally good light, by reason of the fineness of work, colour of material, or other circumstances, and the arrangements made to meet this.

(b) Processes in which there is exceptional exposure to glare, and for what reasons.

(c) Processes in which the lighting is generally inadequate, with detail of a few of the worst examples met with.

(d) Examples of special means of lighting, or of protection from glare, and their efficiency.

Reports were received from 30 districts out of a total of 51. Many industries are mentioned as requiring exceptionally good light on account of the nature of the work. For example, Cotton Clothing Factories, Letterpress Printing, Engraving, Machine Sewing, Embroidery, Clock and Watch Making, Electric Glow-lamp Making, &c., &c. Among the trades which require an exceptionally good light, on account of the colour of the material, are mentioned : Black Silk Weaving, Calico-Printing, Pottery-Making, and Paint-Mixing. Next there are mentioned industries in which cleanliness and good sanitary conditions are of exceptional importance, such as Laundries, Bakehouses, Confectioners, Wool-Sorting, and the manipulation of dangerous wools and hides. Industries in which the avoidance of accidents require special care include Dry cleaning (danger of fire), Power Press Processes (metal-box making), and Iron Foundries.

A number of processes are mentioned in which there is exceptional exposure to glare. For example, we have—

(a) Processes involving of molten or hot metal or glass.

(b) Processes involving the examination of incandescent surfaces such as gas works (retort houses), cement works, electric glow-lamp and incandescent lamp factories, etc.

(c) Processes in which electrical discharges take place.

(d) Processes in which glare is liable to be caused by the position of the light source, such as :—

Letterpress printing works (composing frames).

Wholesale tailoring (sewing machines).

Hemstitching (sewing machines).

Boot factories (various machines).

Motor-repair works (use of portable unshaded lamps).

Photography by arc or flash light.

Hollow ware turning (the room is purposely darkened and a lamp placed in the opening of the ware, in such a position that the light source is between the workers' eye and his work).

Silver and electro-plate works (burnishing, owing to mirror reflection from the polished surface).

Finally, there are a number of processes in which the lighting is frequently inadequate, such as cotton spinning mills, iron and tin plate mills, foundries, ship-building and repairing works, underground bakeries, and basement rooms in factories. This appendix also contains a note of some interesting devices for mitigating the effects of glare, such as the use of large white reflecting surfaces as a background, or of white tissue paper to diffuse the light, the use of smoke glass, &c.

In Appendix VI. we find a series of past reference to lighting in various reports and investigations, among which the Report of the Departmental Committee on Accidents in Factories and Workshops receives special mention. The evidence in this report specifies a number of processes and industries in which the risk of accidents is accentuated by insufficient light. We also find here a reference to the following industries in which insufficient light tends to cause unsanitary conditions, and for which adequate lighting is required in general terms :—

Fruit Preserving.

Bakehouses (underground).

Vitreous enamelling of metal or glass.

Metal Grinding with wet stones.

EXISTING REQUIREMENTS REGARDING LIGHTING IN FACTORIES, SCHOOLS, &c., IN VARIOUS COUNTRIES.

Appendix VII contains quotations of the existing requirements as to the Lighting of Schools and Factories in the British

Empire and in the legislation with regard to factories of this country. Appendix VIII. contains similar information regarding foreign countries.

The general conclusions to be drawn from these regulations have already been mentioned in the Report. Readers of the ILLUMINATING ENGINEER will recall that the regulations of the Board of Education, with regard to Schools, came before the notice of the Joint Committee, appointed by the Illuminating Engineering Society in 1912, to consider this subject.* A useful summary of the factory legislation in various countries, bearing on lighting, was given some years ago in a report presented to the Conseil d'Hygiene de la Seine.† In some cases these regulations have since been modified, and the latest references to them are here given *in extenso*. Most of the requirements, with regard to factories, schools, and other buildings in the United Kingdom, have to deal with daylight illumination, and prescribe the amount of window space and similar matters. Of special interest is the following from the Factory Act in New South Wales, which prescribes a definite standard :—

Every part of a factory in which persons are employed, or any passages or portions of a factory which may at any time be used by an employee, must have light equal to 10 candle meters, that is, light equal to that given out by an ordinary stearine of paraffin candle of six to the lb., at a distance of 12 inches from the flame. When such lighting is found by test to be below that standard, the Inspector may require the occupiers to make provision (preferably where possible by window openings or otherwise) to provide the natural or artificial lighting necessary to bring the lighting up to the standard named above.

Another section of the appendix contains a summary of the requirements as regards lighting in the following countries : Austria-Hungary, Belgium, Denmark, France, Germany, Holland, Italy, Norway, Sweden, and the United States of America. In most cases we find that the regulations are of a general character, and refer mainly to daylight illumination. As a rule "adequate lighting" is required in general terms, and in some instances special recommendations are made with a view to avoiding any possibility of fires arising through the use of artificial light among inflammable

* *Illum. Eng.*, London, July, 1914.

† *Illum. Eng.*, London, Vol. II., 1909, pp. 292, 373.

materials. It is to be noted that in several countries, for example, Belgium, Denmark, and Holland, the requirement of adequate lighting is particularly emphasised in view of danger arising through insufficient lighting. Thus in Belgium, it is stated that :—

All places where any work is carried on, or over which persons are liable to pass, shall be illuminated sufficiently to enable machinery, transmission gear, and other sources of danger to be distinguished.

The lighting of the plant and appliances used in the places specified in the preceding article shall be so installed, arranged, and maintained as to afford all possible security to the persons employed.

In Holland, in the case of certain processes involving fine work (such as embroidery, sewing, composing, draughtsmanship, working in gold, silver, and precious stones), an intensity of 15 metre-candles is prescribed; in other processes requiring good light the illumination must be at least 10 metre-candles. Furthermore, a young person or a woman must not be employed in a factory or workshop unless it fulfils certain conditions. For example :—

(a) *In any workroom which is not adequately lighted during the period of employment ;*

(b) *At any place of work which cannot be protected from the direct rays of the sun, if the district inspector of factories is of opinion that the conditions would be injurious to the young person or woman ; and*

(c) *In workrooms in which during the time between 9 o'clock in the morning and 3 o'clock in the afternoon artificial light must be used in order to obtain adequate illumination, except in so far as exceptional meteorological conditions make the use of artificial light necessary.*

Another interesting point is that in the case of young people or women, the illumination presented is increased to 30 metre-candles in the case of fine work, and 20 metre-candles in the case of ordinary work.

In addition to the general requirement, special conditions as regards lighting are being made for certain industries, and it is laid down that the illumination must be sufficient to enable the persons employed to find their way about in safety.

In Norway, again, the need for good illumination as a matter of safety is recognised in the requirement :—

All workrooms shall be adequately lighted by natural or artificial means, in such a way that all moving parts of machinery involving, when in motion, danger to persons employed, may be clearly distinguished.

In all workrooms in which explosive or readily inflammable gases, fumes or dust are or may be generated, artificial lighting shall be produced by appropriate means.

In Sweden the only legal requirements occur in a recent Act for the protection of labour, which enacts as follows :—

For the prevention of accidents arising from work the employer shall observe the following regulations in particular :—

(a) *Satisfactory illumination shall be provided.*

For the prevention of illness arising from any process the employer shall observe the following requirements in particular :—

(b) *The work shall be carried on in a suitable and sufficient light.*

More precise instructions are contained in two circulars distributed from the Swedish Factory Department :—

Adequate lighting must be provided not only for workrooms and workplaces, but also for stairways, passages, and transmission gear rooms.

Workrooms should be provided with good natural lighting.

Artificial light should be convenient and adequate. During working hours all moving parts of the machinery and all obstructions on the floor which might be productive of danger, hoist and stair openings, breaks in the floor and similar openings, should be well lighted.

Stairways, passages, and yards should always be adequately lighted.

In France the existing requirements appear to be mainly concerned with the safety of the illuminants as regards fires. It is also required that :—

“ All indoor premises used for the carrying on of work, their annexes, and especially the passages and stairways, shall be adequately lighted.”

In Germany we find among the Imperial requirements :—

“ In particular care must be taken to provide adequate lighting.”

While in the Austrian Empire, the new Factory Act requires employers “ to provide the workrooms and shops with adequate artificial light.”

Reference is also made to the necessity for keeping premises as free from dust as possible.

The question of lighting does not appear to have received very much attention in the legislation of most of the United States of America, but there is in most instances a Factory Inspection Law, in which the inspectors are required to satisfy themselves, amongst other things, that the lighting arrangements are adequate for the well being of the

persons employed. Most of the requirements specified by the authorities relate to daylight illumination, prescribing the amount of window space, &c.

In the State of California there is a special provision with regard to unhealthy basements, cellars, or underground apartments used as workshops.

Particulars are also given of the requirements for the lighting of schools in some countries. In this respect also Sweden appears to give an exceptional amount of attention to artificial lighting.

It is stated that :—

In the selection of artificial light sources, care should be taken that these give sufficient and soft light, without glare and shadows, and it is found that a light source of about 25 candle-power at a distance of one metre is sufficient for reading and writing.

*The lamps must be so placed that the pupils are not compelled to look either straight at them or directly past them. They must, therefore, be fixed sufficiently high and be provided, as a rule, with suitable globes or shades, constructed, for instance, of opal or ground glass.** The Swedish requirements are also of interest, in that they discriminate between the requirements of various types of class rooms.

With regard to daylight illumination, we find that in most cases the recommendations refer to the area and position of windows and the shape of schoolrooms, with a view to obtaining the maximum admittance of light. The height of the window sill is also frequently specified, and in Belgium and Sweden the desirable dimensions of schoolrooms are also indicated. In Europe as well as in several states of America, the desirability of light walls and ceilings is pointed out. Unilateral lighting is generally preferred. Speaking generally, the conditions as regards natural lighting of schoolrooms have received more attention than artificial illumination.†

* It is interesting to observe that these recommendations are in close accordance with those suggested by the Illuminating Engineering Society in this country. (See "The Artificial Lighting of Schools," *Illuminating Engineer*, July, 1913.)

† Here again it is interesting to compare the information collected regarding the requirements of various countries with that published in the *Illuminating Engineer* in connection with the inquiry into the Daylight Illumination of Schools (*Illuminating Engineer*, London, Jan., Feb., and July, 1914).

RELATION BETWEEN ACCIDENTS AND INADEQUATE LIGHTING.

In Appendix IX. there is a study of accidents in factories compiled by the Joint Secretaries of the Committee (Mr. D. R. Wilson and Mr. C. C. Paterson).

In order to discover the relationship (if any) between work with artificial light and liability to accidents, use has been made of a special return of all reported accidents for 1913 and part of 1914, in which the number of accidents occurring each month from the following causes :—

- (a) Machinery moved by mechanical power,
- (b) Molten metal and hot liquid,
- (c) Struck by falling body,
- (d) Persons falling,
- (e) All causes,

are tabulated for a large number of industries.

In analysing the accidents three general methods have been employed :—

(1) Diagrams have been prepared showing the monthly percentages of accidents due to various causes. In these the accidents from a given cause in any industry are expressed as a percentage of the total accidents occurring in that industry *from that cause, during the full period of 14 months, under consideration.*

(2) Diagrams have been prepared, showing for each month the relative number of accidents due to various causes. In these the accidents are expressed as a percentage of the total number *due to all causes* occurring in that industry *during the month in question.*

(3) An attempt is made to calculate normal accident rates from each cause during the months that no artificial light is used, and, by applying these rates in the daylight period of employment during the winter months to estimate the accident rates during the use of artificial light.

It will be observed that methods 1 and 2 have both their particular advantages. Method 1 is unaffected by changes in the number of accidents due to causes other than the one under consideration. But it takes no account of the number of working hours, nor the number of persons at work in each month.

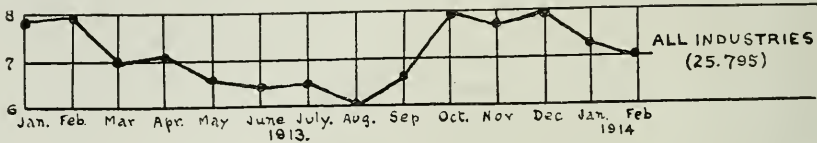
Method 2, on the other hand, eliminates the effect of the variations in the number of persons working and the number of working days. But the true character of the curve may be masked by changes in the number of accidents occurring in the industry from causes other than that under consideration.

In the report a series of diagrams prepared by each of these methods is given. The curves based on method 1 show a

general drop for August, due, doubtless, to the holiday season. Generally speaking, the curves do not possess any characteristic form, *excepting for accidents due to persons falling.* In this case, as is shown by the curve we reproduce, there is a

tion of buildings, which are practically daylight industries, and in these, these considerations serve to show the necessity for careful analysis in considering statistics of accidents.

In applying method (3) certain assump-



Accidents due to persons falling. Showing marked increase in number of accidents during the winter months, when artificial light is mainly used.

marked increase in the number of accidents during the winter months. This would appear to be a natural result. For, of all the varieties of accidents mentioned, those resulting from people falling seems most likely to be effected by insufficient illumination. On the other hand, there are certain sections, such as the construc-

tions are made as to the hours of working, and the period during which artificial light is applied. On this basis a summary of the accidents during daylight and artificial light can be prepared, and in the following table we give the results for persons falling and other accidents due to all causes.

Causa- tion.	Industry.	Total accidents.		Day- light Accident Rate per Hour deduced from summer months).	Accidents during winter months.		Artificial light Accident Rate per Hour	Per- centage of differ- ence between Daylight and Arti- ficial light Accident Rates.
		Summer months (ex- cluding August).	Winter months.		Day- light.	Arti- ficial.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Persons falling	Textile	694	980	0.58	580	400	1.01	+76
	Founding	193	287	0.161	161	126	0.32	+99
	Shipbuilding ..	1,276	1,898	1.06	1,065	833	2.12	+99
	Drink	202	270	0.16	169	101	0.25	+52
	Docks	715	1,072	0.59	598	474	1.20	+102
	Building	274	330	0.22	229	101	0.25	+12
	Engineering ..	1,334	1,895	1.10	1,107	788	2.08	+93
	Other industries not specified ..	3,893	5,240	3.25	3,250	1,990	5.06	+56
	All industries ..	8,581	11,972	7.16	7,159	4,813	12.32	+71
	Textile	7,380	9,744	6.17	67,165	3,579	9.11	+46
	Wood	1,871	2,320	1.56	1,563	757	1.93	+24
	Founding of Metals	3,562	4,217	2.98	2,976	1,241	3.16	+ 6
	Shipbuilding ..	7,355	9,094	6.15	6,144	2,950	7.51	+22
	Drink	965	1,233	0.81	806	427	1.09	+35
	Docks	4,052	5,402	3.39	3,385	2,017	5.13	+01
	Buildings under con- struction ..	833	926	0.70	696	230	0.08	+17
	Engineering ..	16,570	20,838	13.76	13,942	6,896	18.20	+32
	Remaining industries not separately scheduled ..	30,799	38,491	25.75	25,728	12,763	32.48	+26
	All Industries ..	73,387	92,265	61.27	61,405	30,860	79.17	+29

It will be observed that in nearly all cases the accident rate by artificial light is very considerably greater than by daylight. The difference is particularly marked in the case of accidents due to persons falling. In the founding, ship building, docks, and engineering trades, the increase of accidents due to this cause is in the neighbourhood of 100½ per cent. The smallest increase occurs in the case of the construction of buildings for which, being a daylight industry, no difference is to be expected.

In addition we reproduce a table, giving particulars of fatal accidents per month in mines.

AVERAGE NUMBER OF FATAL ACCIDENTS
PER MONTH IN MINES.

	Summer	Winter	Percentage Difference
1912.			
Underground	110	88	—20
Surface ..	14	18	+29
1913.			
Underground	91	89	— 2
Surface ..	11·2	16·2	+45

It is interesting to notice the radical difference in the number of accidents underground and on the surface. During 1913, for example, the number of accidents underground was slightly *less* during the winter than in the summer; whereas on the surface the number of accidents in winter was as much as 45 per cent. greater than in the summer. This seems to point strongly to the conclusion that the conditions of illumination are a material factor in the causation of accidents.

THE EFFECT OF ILLUMINATION ON VISUAL ACUITY.

Appendix X. contains an article on "The Influence of Lateral Illumination on Visual Acuity," by J. Herbert Parsons, a member of the Committee, which is reprinted from the Royal London Ophthalmic Hospital Reports (Vol. xix., Part 111).

The paper contains a summary of various researches which bear on the relation between illumination and acuteness of vision, reference being made to the well-known experiments of Uthoff in 1885.

An important point is the effect of adjacent lights on the impression received

by the eye. This has been studied by Cobb in the United States, who remarks that "light from a bright source entering the eye reduces the visibility of an object more, the brighter the source, the lower the brightness of the object and the smaller the angle subtended by the two." The effects are very complicated, however, and in special circumstances high lateral illumination may actually increase visual acuity. It is pointed out by Cobb that the unpleasant feeling of dazzling and the disturbance of vision produced by dazzling are quite different things, and, apparently, are also distinct from the effect of bright light on visual acuity.

Appendix XI. contains an extract from Professor Snellen's Bowman Lecture in 1896. This is of considerable interest historically, as it shows that even at that early date a standard of illumination for factories and workshops was under consideration. The following is the extract:—

Another subject on which these observations may throw light is the question, "What intensity of light is required for trades in which a good visual acuity is essential?"

We were led to start these observations by a question to this effect addressed to us by our Government. In obedience to Art. 6 of the law of 20th June, 1895, on factories, regulations were wanted for the required illumination of factories and workshops, and the question submitted to us was: "Is it possible to determine the maximum amount of light necessary to the workman with normal eyes for a certain sort of work. And, further, is such an amount of light is to be determined, is there a practical method to measure that amount?"

To answer these questions we set to work in a practical way, and repaired with the photometer to workshops, in order to determine the intensity of daylight at different times, and further, when twilight begins to fall, to ascertain where at the waning of daylight the want of light begins to impede the man's work. In a printing business we found this to be the case for compositors when the illumination sinks below 15 m.c. With an intensity of 15 m.c. a visual acuity of 6/6 is the extreme limit. As a rule, all work is arranged so that it can be done at this vision. But for the man to have his whole visual acuity at his disposal, it is necessary that in the long run a much greater intensity of light should be afforded.

If, however, the intensity of light at dusk is not to fall below 15 m.c., we shall be sure to have in the daytime an intensity of between 30 and 50 m.c. In answer to the questions which were laid before us, we came to the following conclusions:—

"That in every workshop a minimum amount of 15 m.c. is necessary for work resembling reading, whereas a minimum of 10 m.c. will do for coarser work, *e.g.*, that of carpenters and blacksmiths; that in broad daylight the required amount is between 30 and 50 m.c., and

that it must be possible to exclude direct sunlight. The determination of the intensity can be done best by means of a Weber's photometer."

Following this we find results of a series of enquiries among ophthalmologists and ophthalmic surgeons undertaken by F. R. Cross, F.R.C.S., with a view to obtaining statistics or information as to the prevalence of eye trouble among people in various trades. In some cases insufficient light is regarded as aggravating effects of strain on the eyes. Many of the replies lay stress on the need for careful distribution of lights and proper methods of shading; others mention various methods of protection employed by glass-blowers, electric-welders and others, who have to deal with intensely brilliant lights.

A circular letter has also been addressed to various associations concerned with fine work, asking for information of specific cases of injury to the eyesight caused by working with insufficient light or with a badly-arranged system of lighting.

Here again it appears difficult to trace specific instances, for the opinion is expressed that bad eyesight would certainly follow in any case where work-people had a strain on their eyesight through the fault of bad lighting; at various times complaints have been made by weavers at certain mills of the difficulty of following their work on account of the bad lighting.

The remaining appendices are devoted mainly to the special researches carried out by the Committee. These fall into two parts; the experiments made at the National Physical Laboratory and the tests carried out in various factories throughout the United Kingdom.

EXPERIMENTS AT THE NATIONAL PHYSICAL LABORATORY.

The experiments at the National Physical Laboratory deal with a number of points of which opinions have often been expressed, but on which few data have hitherto been available. The tests were carried out in a room with white walls, which, however, could be screened with black curtains when it was desired to test the effect of reflection. Three systems of illumination were installed: (1) *Direct lighting* by unobscured metal filament lamps with ordinary opal glass shades, (2) *Indirect lighting* by metal filament lamps in inverted white reflectors, (3) *Shielded lighting* in which lamps, similar to those in system (1) were enclosed in illuminium shades of approximately

parabolic form, which completely shielded the eyes from the direct rays of the lamps. By means of resistances placed in circuit of the lamps, any degree of illumination up to the maximum of approximately 12 ft.-candles (underneath the lamps), can be obtained.

Effect of Absorption of Light by Material.

Some tests were carried out on seamstresses taken from the workrooms of some of the principle outfitters and also tailors from the East End. The operators were asked to work on various materials, varying in hue from white to black, and an attempt was made to ascertain the order of illumination which was considered by the operators satisfactory in each case. Speaking generally, about 5½ ft.-candles was found to be necessary for black material, whilst 1¼ ft.-candles appeared the minimum necessary for white calico. Colours intermediate in hue between these extremes required intermediate values of illumination. The results obtained suffice to indicate the correctness of the relation:—

The coefficient of reflection $\times$ necessary illumination = constant.

In other words a minimum surface brightness of the material worked in should be aimed at.

Observations were also made by the Committee on the appearance of type on cards of various colours. It was again found that the colour had a definite influence on the illumination required; whereas the smallest type on white cards could be read with an illumination of ¾ ft.-candle, similar figures on dark blue cards could not be seen with an illumination of 6 ft.-candles.

Speaking generally, an illumination of 3 to 4 ft.-candles gives the impression of a well-lighted room, whilst from 0.1 to 0.25 ft.-candles would be the order of illumination which would suffice for corridors.

Experiments on Glare.

Experiments were also made to test the effect of glare. It is pointed out that the effect of a bare lamp in the direct range of view depends very materially on the intensity of illumination in the neighbourhood of the observer. For example, in one case observers were asked to study a test card while a 100 candle-power lamp was placed in front of them, in such a way that the vertical distance between the lamp and the test card subtended an angle of 20 degrees at the observer's eye.

The time required to read the figures on the cards with the lamp present and removed was noted. It appeared that when the illumination on the card was only 0.5 ft.-candles the glare from the expressed source of light rendered it practically impossible to distinguish them; but when the illumination was over 2 to 4 ft.-candles there was no diminution of ability to read the figures. (This experiment suggests an additional reason for desiring a high value of illumination on the work, namely, that insufficient illumination, besides adding to the difficulties of perceiving detail, also accentuates the effect of glare.)

Comparison of Direct and Indirect Lighting.

Another very interesting series of experiments was conducted on the effect of direct and indirect lighting. As far as the observation of the type on cards is concerned it would appear that there was no difference in the two cases, provided the direct lights were so placed that inconvenient reflection of light from the card was avoided. But in the case of fabrics with irregular surfaces, embossed papers, engraved copper plates, etc., it appeared that a considerably greater illumination was required by indirect illumination than by direct lighting. In these cases the perception of detail apparently depends mainly on the contrast between the brightness of the ground surfaces, and that of the shadows cast by the embossed detail, or on the variation of brightness over the surface of such detail. The preference for direct lighting may, therefore, be due mainly to the fact that the shadows shown by indirect light are less intense, and that the variation of illumination over a curved surface is much less marked with diffused light.

Some of the main conclusions arrived at as the result of these experiments are as follows:—

(1) The illumination required for the perception of detail in materials having a low coefficient of reflection is greater than for those which reflect more strongly and other things being equal is inversely proportional to such coefficient of reflection; that is to say, for equal visibility there must be constant surface brightness.

(2) The visibility of detail in self-toned portions of fabrics, embossed paper, and similar substances, depends on the unidirectional character of the light illuminating them. It follows and has been shown experimentally that the ability to distinguish detail in such substances is

for the same illumination much greater by direct than by indirect light.

(3) Work such as sewing may be comfortably performed on the darkest materials with an illumination of 5 to 6 ft.-candles (direct lighting). For white calico $1\frac{1}{2}$ ft.-candles was found sufficient, and intermediate shades were found to lie between these values.

(4) The observations on the phenomena of glare have not as yet yielded definite numerical results. They have shown, however, that the presence of a bright lateral light, although causing a feeling of annoyance, does not actually diminish ability to distinguish detail unless the surface brightness of the object viewed is relatively low.

Records and Summaries of Illumination Measurements in Factories.

Appendix XV. contains a complete account of the sources of measurements made in factories throughout the United Kingdom.

In taking the observations special attention was directed to:—

(a) The illumination of floors and gangways;

(b) Illumination where work was being carried out.

A distinction has to be drawn between the tests of natural and artificial illumination. Seeing that the intensity of natural light varies from hour to hour and day to day observed absolute measurements are not a very useful method of investigating the admission of daylight, and no records of the illumination on isolated occasions suffice of themselves to afford a criterion by which to judge the illumination. It is necessary to relate the illumination at any moment indoors with the unrestricted illumination outside at the same instant. This relation is expressed as a "daylight factor" for any point in a room, and is a measure of the lighting efficiency of the building at this particular point. Naturally this factor varies very greatly according to the position of windows, but it should be, within wide limits, independent of the time of the year or the external meteorological conditions.

Experience shows that in roof-lighted buildings, such as weaving sheds, the daylight factor is of the order of two per cent. On the other hand, at the centre of some workrooms depending entirely on lateral illumination, the factor falls as low as 0.01 per cent. In Appendix XVI. charts showing the variation in illumination in the course of the day and throughout the year are given. From these

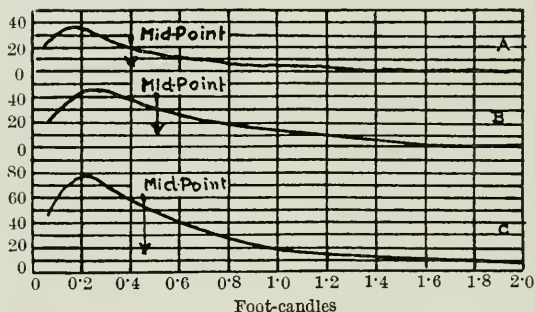
figures it appears that an average day in December the illumination varies from 500 foot-candles at 10 a.m. to 700 foot-candles at mid-day. If the daylight factor at a point in workrooms does not exceed 0.4 per cent., its illumination will only reach two foot-candles from about 10 a.m. to 2 p.m., and at other times of the day it will be below this. Such a room could not be regarded as adequately lighted in December without additional artificial light, although in June, with an outside illumination at mid-day of the order of 4,000 foot-candles, the lighting would probably be satisfactory from 6 a.m. to 6 p.m.

In these curves the illumination is plotted against the number of factories in which a certain value of illumination is encountered. The two principle features to be noted in any one of these curves are :—

(a) The mid-point ;

(b) The general contour and distribution of area of the curve.

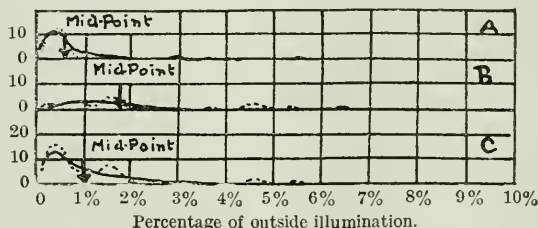
By the "mid-point" is meant the point above and below which there is an equal number of observations. In most curves there is a well defined maximum, which in many instances occurs at a point low down in the scale of illumination. The mid-point is of particular interest in



Frequency of Occurrence Curve for Artificial Lighting of Factory Floors.

A—Foundries. B—Other Factories than Foundries.

C—All Factories visited, including Foundries.



Frequency of Occurrence Curve for Daylight Factors.

Combined Roof and Side Lighting.

A—Foundries. B—Other Factories than Foundries.

C—All Factories, including Foundries.

In analysing the results of these investigations, as regards natural and artificial lighting, the Report makes use of "frequency of occurrence curves," a few of which we reproduce herewith.

view of the recommendations contained in the Report as it gives a fair measure of the average illumination which might be expected in modern factories of a particular class. The following figures are

of special interest as showing the mid-point daylight factors made in several classes of factories :—

	<i>Daylight Factor.</i> Per cent.
1. Roof-Lighting :—	
Foundries	1.4
All Factories, excluding Foundries	2.3
All Factories, including Foundries	1.9
2. Combined Roof and Side-Lighting :—	
Foundries	0.6
All Factories, excluding Foundries	1.8
All Factories, including Foundries	1.0
3. Side-Lighting only :—	
All Factories	0.25

In the following table corresponding figures are given for the mid-point values of artificial illumination as measured on the floors of factories. It will be seen that

these values are in general well above the recommended minimum values in the Report.

<i>Factory.</i>	<i>Artificial Light.</i> Mid-point on Floor. Foot-candles.
Foundries	0.4
Engineering Shops	0.6
Weaving Sheds ..	0.4
Lace and Hosiery Factories ..	0.35
Clothing Workrooms	0.85
Spinning Mills ..	0.6

A large number of figures are also given for the intensity of illumination encountered at the actual point where the work is carried on. In this case the values naturally vary between wide limits the higher illumination representing exceptionally good conditions of illumination and the lower figures values which would probably be considered insufficient. In the following table we summarise

CONDITIONS OF ILLUMINATION IN VARIOUS FACTORIES.

<i>Nature of Factory.</i>	<i>DAYLIGHT.</i> DAYLIGHT FACTOR %.			<i>ARTIFICIAL LIGHT.</i> FOOT-CANDLES.		
	On Floor.	At Point of Work.		On Floor.	At Point of Work.	
	Mid-Point.	Range of Values.	Mid-Point.	Mid-Point.	Range of Values.	Mid-Point.
TEXTILE—						
A. Weaving	1.5	0.3—5.2	2.7	0.4	0.98—8.7	2
B. Spinning—						
(a) Rooms containing much machinery	0.8	0.17—3.2	0.6	0.6	0.26—5.6	0.65
(b) Mill Spinning Rooms						
C. Lace and Hosiery—						
(a) Lace	0.35	0.56—2.0	0.65	0.35	0.42—2.35	0.7
(b) Hosiery						
(c) Winding machines						
ENGINEERING—						
A. General Engineering						
(a) Machine Shops	1.2	0.23—5.2	1.5	0.6	0.57—10	1.6
(b) Rooms for Bench work		0.54—11	1.8		0.49—5.8	1.85
(c) Forges and Heavy Work		0.3—3.4	1.0		0.47—2.2	1.0
(d) Woodworking and Pattern Shops		2.1—2.9	—		2.8—4.4	—
B. Foundries	14.*		1.4*			
MAKING UP OF CLOTHING, ETC.—	0.6†	0.58—25%	0.6†	0.4	0.18—2.3	0.4
(1) Sewing Coloured Cloth	1.2	0.44—5.0	1.6	0.85	0.76—14	3.6
(2) Cutting and Pressing		0.5—1.1	1.3		1.45—3.9	2.0
(3) Sewing on White Linen		0.27—13	3.3		2.1—5.3	2.5

* Roof Lighting.

† Combined Roof and Side Lighting.

in a general form some of the figures given in the Report for the various classes of factories visited.

MISCELLANEOUS INDUSTRIES.

Nature of Work.	Daylight Factor at Point of Work.	Artificial Illumination at Point of Work. Foot-candles.
	%	—
Drawing office ..	0.13	0.25
Cotton bag-making ..	5.8	3.1
Tapestry ..	5.8	8.2
Xmas card printing ..	2.9	8.4
Print colouring ..	0.16	7.0
Printing ..	1.3	1.65
" ..	0.28	2.20
" ..	2.5	3.4
" ..	1.7	0.93
Printing and box- making ..	0.32	2.70
Box-making ..	3.4	1.2
Chocolate - making and packing ..	0.34	0.83
Cocoa packing ..	0.34	1.2
Chocolate packing..	0.6	0.82
Burling " ..	0.9	0.90
	5.0	7.0

We may say that the complete data given on this point in the Report are well worthy of study by those concerned with the lighting of these classes of factories.

Appendix XVI. contains a special contribution by Mr. C. C. Paterson and Mr. J. W. T. Walsh on daylight illumination, in which the nature of the daylight factor and methods of measuring it are explained. Of special interest are the curves showing the variation in illumination on average days in June, September, and December and the average illumination for each month during the year. This appears to be the first time that the values have been completely determined experimentally in this country, although corresponding figures have been obtained on the Continent and in the United States.*

The final Appendix (XVII.) contains a brief explanation of the chief essentials of modern illumination photometry.

* *Illum. Eng.*, Lond., Vol. VII., 1914, pp. 15, 79. Vol. I., 1908, pp. 685, 686.

PRACTICAL LIGHTING IN A BLACKSMITH'S SHOP.*

A SIMPLE but effective method of lighting for use in making horseshoes is installed in a blacksmith's shop at Salem (Mass., U.S.A.).

Three round openings, 9.5 in. in diameter, were sawed in the inside boarding of the double wall partition, leaving a space the depth of the joists, about 4 inches. In each opening was placed a 25-watt tungsten lamp, with a concave metal reflector behind it.

The three units are situated 7½ ft. apart, in a row 32 in. above the floor. This location permits the light to shine directly on the work, while the blacksmith is hammering the shoe on the hoof held on his knee, and does away with inconvenient flexible cords.

* *Electrical World*, July 10th, 1915.

FIRST REPORT

OF THE

Departmental Committee

ON

LIGHTING IN

FACTORIES

AND

WORKSHOPS.

Chairman :

DR. R. T. GLAZEBROOK, C.B.

Price, post free, 1s. 2d.

EYRE & SPOTTISWOODE, LIMITED.

Sale Office for Parliamentary
Papers, Acts of Parliament, and
Government Publications,

EAST HARDING STREET, LONDON, E.C.

SHORT NOTES

ON

ILLUMINATING ENGINEERING.

THE MELTING POINT OF TUNGSTEN.

SINCE the metal filament lamps first made their appearance there has been much speculation on the melting point of tungsten and the limiting intrinsic brilliancy that might be expected from filaments of this material.

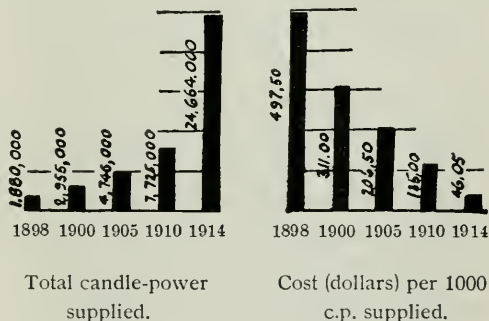
Some light is shed on this point by a recent series of researches by Irving Langmuir,* who brought two tungsten electrodes into a molten condition by the passage of an alternating arc. An intrinsic brilliancy of 7,200 candles per square centimetre was attained, and it is estimated that the temperature of incandescence at melting point was very close to 3540° abs. or 3267° C.

Another interesting fact mentioned by Langmuir is the unequal brightness of different portions of the spirals of tungsten filament. The interior portions of the helix appear to have a brightness quite twice that of the external portion. This difference cannot be ascribed to variation in temperature, and is thought by the author to be due to reflection of light in the interior of the helix. This suggests that, other things being equal, the light-giving efficiency of a helical filament will in general be somewhat less than that of a plain wire, owing to the fact that the folds of the helix cause a certain amount of obstruction of light.

* *Physical Review*, August, 1915.

STREET LIGHTING IN CHICAGO.

IN the Annual Report of the Commissioner of gas and electricity for the City of Chicago (1914) detailed costs for the last few years are given, and in a recent issue of the *Electrical World* these are assembled in tabular form and compared with the corresponding amount of light provided. It will be seen that the total candle-power has risen from 1,800,000 in 1898 to 24,664,000 in 1914. Simultaneously the cost per thousand candle-power has diminished from \$497.50 to \$46.05.

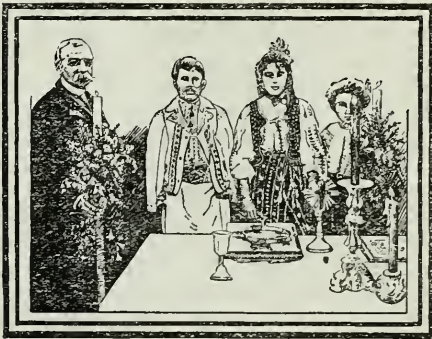


Owing to the advance in modern methods of illumination Chicago is thus getting about thirteen times as much light as was provided 16 years ago; but is only paying for this vast increase about 20 per cent. more than the original sum.

LIGHT AND SUPERSTITION.

SOME years ago we published a series of articles by D. M. Gaster entitled "Light in Custom and Superstition," in which many instances were mentioned of the use of light in connection with ceremonies among primitive peoples, such as weddings and the burial of the dead. In such cases we find a constant relation between the kindling of flames and life—their extinction and death.

Some other interesting examples are quoted in a recent issue of the *Edison Monthly*. "The folk-lore of nations," it says, fairly bulges with references to the lamp, the torch and the candle, which seem, in consequence, to have guided men's actions in the critical occasions of life quite as much as they have directed his footsteps by night."



A Roumanian Wedding.

Decorated candles play an important part of the ceremony and are kept by the bride and groom for the rest of their lives.

It is gratifying to note that among the Romans one goddess, "Esta," paid particular attention to lights, and is believed to be closely related to Hestia, a Greek goddess with similar functions. Besides playing an important part in wedding ceremonies (note, for example, the candles in the illustration of the Roumanian marriage), light is regarded in India as a safeguard against cholera and other sicknesses; "the most obstinate disease will yield if a new earthen pot, clean washed and filled with certain objects, be taken to the cross roads with a light made of threads dipped in oil, and there broken."

Light has also been credited with a certain power over the elements, and candles were kept burning during a thunderstorm.

In Wales they speak of the "canwyll corph," or "corpse candle," which is supposed to visit the home of a person about to die; in Lancashire candles formed an essential part of the ceremony of "lating the witches."

But perhaps the most curious instance of all customs in which candles figure is furnished by the old auction sales in England. It is stated that one such custom was even sanctioned by Act of Parliament, which directed that herbage should be sold by candle light, and that the last bidder, when the light had burned itself out, should be the purchaser.

At such auctions the bidding was stimulated by the frequent exclamations of the auctioneer, "Get on, gentlemen, please, the light's burning."

FAILURE OF LIGHT DURING AN OPERATION.

THE *Pall Mall Gazette** mentions an incident which illustrates very forcibly the risks of total extinction of light during visits of hostile aircraft, and the importance of the recommendations made by the authorities on this point, and summarised in our July issue (p. 302).

During one of the air raids on the East Coast a well-known surgeon was performing the operation of tracheotomy at a nursing home. When the German aircraft came over the town the electric current was at once cut off. All the lights went out suddenly, and this, too, at the very moment when the surgeon in question was opening the windpipe.

Fortunately it was not the first attack delivered against this place, a fishing and sea-bathing resort. Taught by experience, the operator had made it a matter of habit to warn his nurses and other assistants that lamps should be kept ready for use during all operations which had to be undertaken at night.

This precaution may have saved the small patient's life. With but a trifling delay the tracheotomy was completed and the child is now doing well.

* Aug. 20, 1915.

A NEW METHOD OF COMPARING SOURCES OF LIGHT WHICH DIFFER IN COLOUR.

ONE method which has been used by many laboratories in comparing sources of light which differ in colour is to insert a coloured transparent screen in front of the standard bringing the hues of the two lights to be compared into practical identity. The amount of light absorbed by the screen must be determined once and for all by a separate and careful investigation. Naturally this involves heterochromatic photometry, with all its difficulties, but the comparison can be made by skilled observers, and personal discrepancies reduced by making observations with a number of different individuals and taking a mean.

In a recent paper before the Illuminating Engineering Society in Germany, Herr v. Pirani suggested a new method of making this determination. The curve of sensibility for the human eye has been determined with great care by Ives in the United States and it is therefore possible to construct the average curve of luminosity throughout the spectrum for the white light.

Now if the absorption of the filter used with the standard light is correctly determined throughout the spectrum by observations with a spectrophotometer, a second curve can be constructed showing the luminosity throughout the spectrum as received through this filter. The comparison of the area of this curve with that of the curve showing the total luminosity, gives a measure of the integral absorption of the filter. The advantage of this method is that no heterochromatic comparisons have to be made, providing the results for the standard life are accepted. The question may arise whether other observers would obtain exactly the same results, but in view of the great care with which this determination was made agreement seems probable.

Herr v. Pirani describes some experiments on red, green, blue, and violet filters by which the results obtained by the above method were compared with those obtained from direct observation. Even in these extreme cases the order of accuracy was found to be within 3—5 per cent. It is stated that with the type of filter necessary to bring colours of the light used by a half-watt lamp and an ordinary tungsten lamp into equality, results correct to within one to two per cent. may be expected.

THE FIREFLY AND OTHER LUMINOUS ORGANISMS.

SOME interesting data on this fascinating subject were given by A. F. McDermott in a recent paper before the Illuminating Engineering Society in the United States.

The author shows that the power of producing light is quite widely distributed among animals, but is directly observed in certain insects and marine creatures. Observers agree as to the high luminous efficiency of the light from the firefly, estimated to be between 90 and 100 per cent. In many cases the spectrum is continuous within wide limits. The colour, however, varies, being greenish in some cases and red in others.

A most interesting statement is that the tissue of these organisms can be dried and kept for as long as two years without losing their phosphorescence. The chemistry of the processes giving rise to light is somewhat obscure, but the general belief is that the luminosity is due to oxidation. The study of these aspects is most important, as it may enable us eventually to prepare substances giving a permanent luminosity sufficiently great to render them of considerable practical value, for coating powder magazines and in order to render objects in mines, &c., easily discernible.

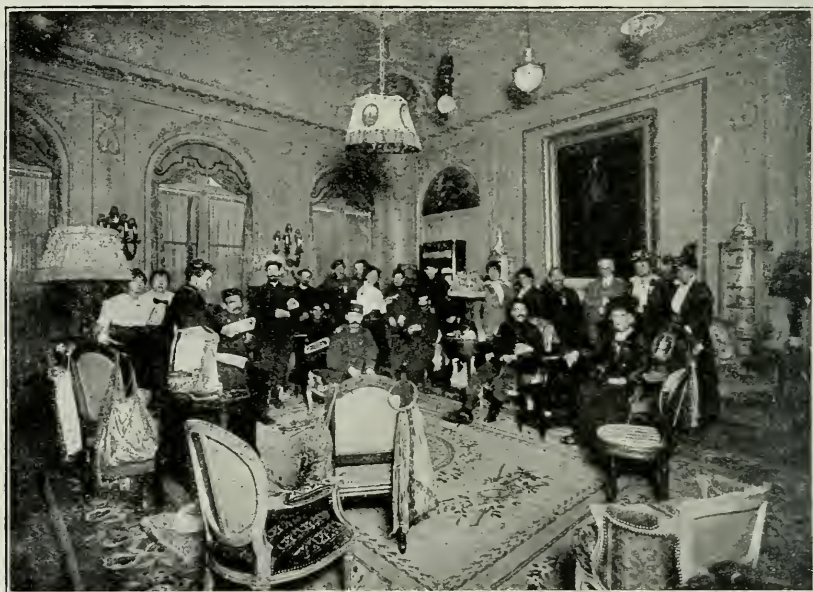
THE HOLOPHANE "OUVROIR" IN PARIS.

IN Paris, as in London, there are many "Ouvroirs"—organisations which are doing admirable work in alleviating the lot of the soldiers in the trenches. The Holophane "Ouvroir" at 156, Boulevard Haussmann, Paris, which is managed by Madame Mary King Waddington and Mrs. Otis Mygatt, was among the very first of these institutions to be started after the declaration of war.

One can hardly imagine a more striking

frances has been spent on clothing which has been distributed to those at the front. Thousands of letters have been received from the trenches expressing gratitude for the services rendered by the "Ouvroir." Many of the writers refer pathetically to friends and relatives who were resident in the invaded area, and whose fate is still uncertain. This anxiety is hard to bear and in the circumstances the friendly assistance of the "Ouvroir" is all the more appreciated.

It is surely appropriate that the Holo-



The Holophane "Ouvroir" (Paris). On the right are seen Madame Waddington (seated) and Mr. and Mrs. Otis Mygatt, by whom the "Ouvroir" is managed.

illustration of the contrast between peace and war than the gathering in the well-known Paris showrooms of the Holophane Co., shown in the photograph. Madame Waddington and Mr. and Mrs. Mygatt appear on the extreme right; among those present are a number of wounded soldiers who came in while the photograph was being taken.

Every day at least 10 to 20 soldiers call and receive help and comfort in various ways. It is stated that since August 6th, 1914, the sum of 40,000

francs has been spent on clothing which has been distributed to those at the front. Thousands of letters have been received from the trenches expressing gratitude for the services rendered by the "Ouvroir." Many of the writers refer pathetically to friends and relatives who were resident in the invaded area, and whose fate is still uncertain. This anxiety is hard to bear and in the circumstances the friendly assistance of the "Ouvroir" is all the more appreciated. It is surely appropriate that the Holo-



TOPICAL AND INDUSTRIAL SECTION.

— • • • —

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]



RAILWAY STATION LIGHTING WITH HALF-WATT LAMPS.

IN our last issue we referred to the improved lighting at the Caledonian Railway Company's station at Glasgow, which is now lighted by Osram Atmos (Half-Watt) lamps. The illustration shows the general arrangements of these

from 0.8—1.6 ft.-candles were recorded. Seeing that a series of measurements carried out some years ago on the main platforms of some of the chief stations in London showed that the minimum was usually of the order of 0.25 ft.-candles, the above values must be considered good lighting and it is evident that the introduction of half-watt lamps



A view of the Caledonian Railway Co.'s Station at Glasgow, lighted by Osram Atmos Lamps.

lamps, which have simply replaced the are lamps previously used and occupy the same positions. As a result there has been an economy of 300 watts on each circuit of four lamps. The illumination is stated to be even and sufficient for the purpose.

It is stated that the illumination in the main hall is now from 1.7—2 ft.-candles, while along the platform values

is leading to a decided rise in the standard of illumination provided.

SIEMENS' CONTRACT.

Messrs. Siemens Bros. Dynamo Works, Ltd., inform us that they have received an acceptance of their tender for the supply of Wotan lamps to the Great Central Railway.

HIGH PRESSURE GAS LIGHTING IN AN ENGINEERING WORKSHOP.

IN this issue we give another illustration of the lighting on an engineering workshop lighted by high pressure gas, namely the workshop of Messrs. Penrose & Co. in Farringdon Road. The illumination is on the Tilley high pressure gas system. Our first illustration shows a main view of the big shop. The lighting was not a very easy problem owing to the fact that the ceilings are somewhat low, and the lamps at a somewhat lower level than they would have been had a loftier room been available. Nevertheless the measurements show that the general illumination is quite high and, considering the circumstances, fairly evenly distributed. Fig. 1 gives a good idea of the general effect of the lighting. The shop contains a considerable amount of machinery, but is not unduly crowded. At the present time the shops are working overtime owing to Government work

Our next illustration shows a gangway at the side of the shop which is lighted in a very similar manner, the illumination in this case being 2 to 4 ft. candles. The large units suspended from the roof are stated to furnish approximately 100 candle-power each. In addition local 500 candle-power units equipped with reflectors will be seen from the benches. Measurements on the jaws of several successive vices give results varying from 10 to 12½ ft. candles which is doubtless ample for all ordinary bench work.

Our third illustration shows a view of a lathe which also received light from the small units, in addition to the general illumination. Here again the working illumination was of the order of 10 to 12 ft. candles. It will be noticed that the small units are equipped with anti-vibration devices and we understand that in spite of the severe test to which they are subjected the mantle breakage is not excessive.

THE MONAZITE SANDS OF TRAVANCORE.

At the commencement of the war much amount of interest was aroused amongst gas engineers by the situation regarding the supply of thorium and cerium and other materials for making incandescent mantles. Attention was drawn to the fact that very large deposits of monazite sand, from which these materials may be extracted exist, in Travancore, India.

We observe that, according to the *Gas World*, special arrangements have been made by the India Office for the working of these concessions by the Travancore Minerals Co., in order to ensure that in future, full supplies of these much-needed materials will be available for British industries. Various conditions for the working of the Company are prescribed, including the appointment by the Secretary of State for India of Sir John Hewitt, as Chairman and Director of the Company.

It is added that Messrs. Hopkins and Williams, Ltd., London, have already been granted, by the Travancore Government, a lease for twenty years of 150 acres of monazite sand ground. A scientific staff has been organised, and it is hoped that operations will be begun in October next.



FIG. 3.—Local lighting of lathe with small 100 c.p. units.

and in the foreground on the right hand side will be seen a pile of cylinders for shells in their initiative stages. Some measurements were carried out down the central gangway and values measured on the floor varied from 1.5 up to 3.5 ft. candles, which is probably exceptionally high for gangway lighting.



FIG. 1.—A general view of large workshop of Messrs. Penrose & Co., lighted by Tilley high-pressure gas lamps.



FIG. 2.—A gangway in the same works lighted by Tilley high-pressure gas lamps. Smaller 100 c.p. units are used to light the benches.

HOLOPHANE INDUSTRIAL LIGHTING.

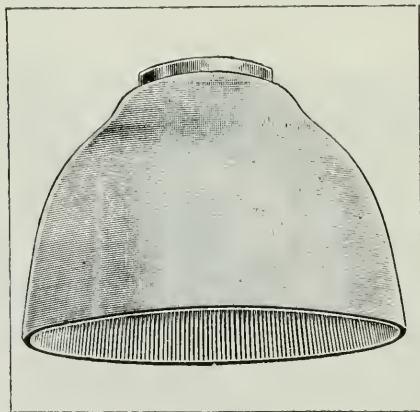
AN opportune booklet issued by Holophane, Ltd., deals with the new Holophane reflectors for industrial lighting. These reflectors are doubtless known to readers of *THE ILLUMINATING ENGINEER*. The essential novelty in their construction is that aluminium cases are spun over the external prisms so as to seal up the reflector completely and prevent any possible accumulation of dust. Being quite smooth internally and externally, the reflector is easily cleaned, and yet all the advantages of the prismatic construction are gained.

The booklet emphasises the chief essentials of good industrial lighting, namely, *the provision of sufficient illumination, the screening of the light sources from the eyes of operators, and the prevention of troublesome shadows*. These requirements are met by the correct shaping and spacing of the reflectors, and detailed tables are given showing exactly what illumination can be secured by spacing the reflectors according to the prescribed rules. On the opposite page we repro-

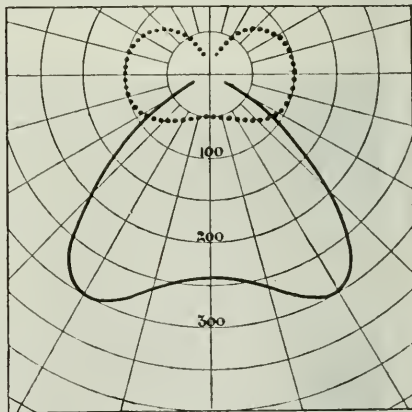
duce a complete page relating to the intensive type, which furnishes the lighting engineer with all the data required in order to predetermine the illumination and secure evenness of distribution. We would like to draw particular attention to the table, showing the height at which reflectors must be suspended in order to obtain a certain illumination. In this case the scale of illumination is arranged in graded values separated at convenient intervals, from 0.5 up to 10 foot-candles, the corresponding heights for the reflectors being given to the nearest $\frac{1}{2}$ foot.

Opposite these data the general appearance and distribution of light from the single unit are shown, thus enabling the illumination under the lamp with local lighting to be also readily calculated.

The booklet contains a table of illumination values for various classes of work. We notice that a distinction is drawn between the illumination required for specific processes and the illumination requisite in the interests of general convenience and safety, for which 0.5—1.0 foot-candles is suggested.



Intensive (I) Type Reflectors.



Photometric Curve.
- - - - Lamp alone — Lamp with Reflector.

Particulars of Holophane "Intensive" Reflectors for Industrial Lighting.

GAS LAMP LOWERING GEAR.

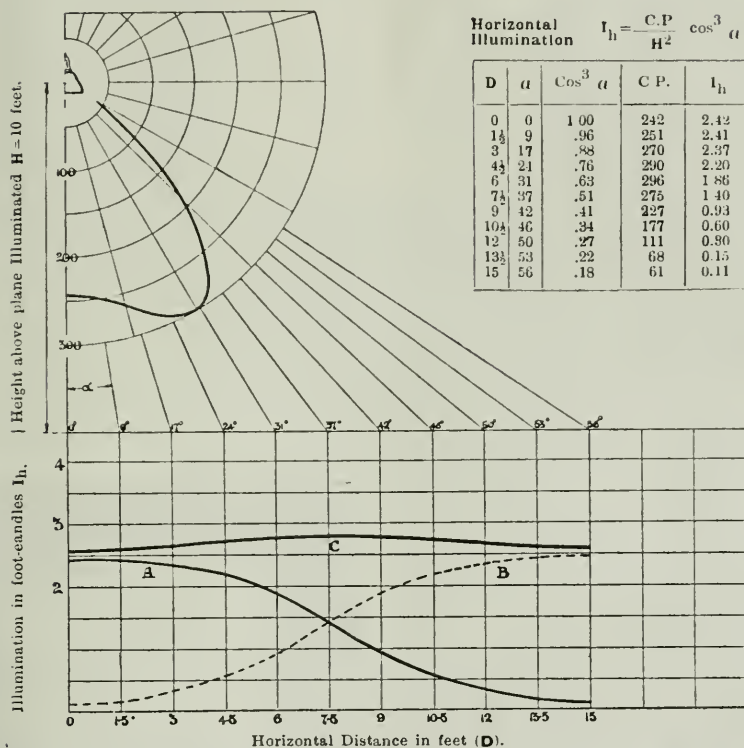
WE notice that the **London Electric Firm**, of Croydon, are making a patent lowering gear suitable for use with gas lamps suspended high up in churches and similar large interiors. The lamps can be lowered by winch, the essential part of the apparatus being the special gas-joint

which does away with all flexible tubing and is free from troublesome complications. The device provides for two supplies so that a bye-pass can be used. As the joint is capable of withstanding pressure considerably in excess of those habitually used in gas lighting the arrangement should be quite a safe one.

Engineering Data

for

Holophane "Intensive" Type Reflectors.



Curves A or B show the distribution of light from the respective units placed at a height of 10 feet. Curve C shows the sum of these two units placed at 15 feet apart.

The above data is calculated for lamps rated at 100 c.p. To obtain values for other lamps use formula:—

$$\left(\frac{\text{C.P. of Lamp}}{100} \right) \times \text{reading}$$

The following table shows at a glance the candle power of the lamp it is necessary to use and the height at which units have to be placed to get any desired foot candle intensity.

Rated Candle Power of lamp.	Horizontal Illumination in Foot-Candles.												
	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0
100	23	16½	13½	11½	10½	9½	8½	8¼	7¾	7¼	6¾	6¼	5¾
200	—	23	19	16½	14½	13½	12½	11¾	11	10½	9½	8¾	8¼
300	—	—	23	20	18	16½	15½	14½	13½	12¾	11½	10¾	10
400	—	—	—	23	21	19	17½	16½	15½	14¾	13¾	12¾	11½
600	—	—	—	—	25½	23	21½	20	19	18	16½	15½	14½
1000	—	—	—	—	—	30	28	26	24½	23	21½	19¾	18½
1500	—	—	—	—	—	—	34	32	30	28½	26	24	22½
2000	—	—	—	—	—	—	—	37	35	33	30	24	26

These heights are obtained by the correct spacing of two units (see graph at top of page.)

RATIO. 1½ : 1 = Distance apart to height,

A NEW TYPE OF ILLUMINATED SIGN.

AN interesting form of sign has recently been installed at Victoria Station and elsewhere in London, and has attracted a considerable amount of attention during the last few months.

The essential principle of the sign involves a combination of the "Tele-writer" device, by means of which any pattern or drawing can be electrically or mechanically reproduced at a distance, with an appliance for projecting this pattern on a screen. The white screen is erected on the platform near the roof on the east side of the Victoria L.B. & S.C. Ry. Station and in this prominent position can be seen by passengers waiting for the trains, from any part of the main platform. The operator sits in a small enclosure a short distance away from the screen. Any desired picture is traced out on a brass plate by a small metal pencil, which is attached to two wires guiding an inking pen operating on a sheet of transparent gelatine paper. When the point of the pencil is applied to the brass plate an electric circuit is completed and the inking pen is thus brought in contact with the transparent paper. Then, owing to the mechanical connection between the pen and pencil, any motion of the latter is reproduced exactly by the former. The drawing is thus traced out in ink on the transparent paper, which is situated in an arelight projector and is thereby thrown on the screen, forming an image of jet black lines on a brilliant white background.

The operator, while sketching out the drawing keeps his eyes on the screen, and the public sees the whole design being sketched out by the pen starting with a blank white sheet and ending with the finished drawing. After the drawing is completed a short time is allowed for it to be seen by the public, and then a new portion of the endless roll of transparent

paper is substituted and the process begins over again.

In this way a large number of advertisements can be shown in the course of the evening, a small weekly charge being made for each advertisement thus shown.

The illustrations are reproduced direct from photographs taken entirely by the artificial light at night in Victoria Station. In the small block a view is shown of picture taken from near the projector. The other photograph was taken from the main platform below, the exposure being selected with a view to showing the sign and also something of the surroundings of the Station. Naturally it is a difficult matter to obtain a photograph to fulfil these exceptional conditions, and the results may be considered satisfactory in view of the difficulty of the problem.



Lumina Bureau Photo.

FIG. 1.—View of the sign at close quarters.

We understand that other installations of this sign will be made in London shortly; it has already been tried for recruiting purposes in Liverpool—and proved almost too successful, attracting a crowd within a few minutes which completely blocked the roadway.

We are indebted for the above account of the working of this apparatus to Mr. Ingle, the General Manager, of Telenews, Ltd., 6, Broad Street Place, London, E.C.



Lumina Bureau Photo.

FIG. 2.—General view, showing the position of the sign as viewed from the platform.

G.E.C. FITTINGS ACCESSORIES.

The General Electric Co., Ltd., have issued their list of "Electric Light Fittings Accessories, 1915" (14th edition). All the usual types of special glassware are illustrated—Superlux, Holophane, Equiluxo, etc., and there is also a special list of cardboard, fancy silk, and fancy glass shades. We note also the new County lantern,

with its specially designed Holophane glassware for use with Osram Atmos (half-watt) lamps. The series of reflectors for shopwindow lighting should be of special utility at the present moment when concealed methods are practically unavoidable; there are also listed luminous signs which are stated to conform with the present lighting regulations.

ECONOMY IN THE USE OF LIGHT.

In the present circumstances, when economy is a national duty, people are being advised to be sparing in the use of light.

We of course fully agree that light should be judiciously used and not wasted, and one of the chief aims of illuminating engineering is to study how it can be applied to the most efficient manner.

On the other hand, people should certainly recognise that illumination is a necessity and not a luxury. It must be wisely utilised, but it cannot be dispensed with. Light is a *tool*, and it is false economy to grudge the expenditure of good illumination which the carrying out of efficient work demands.

This is pointed out in a note in a recent issue of the *Gas World*, in referring to some remarks by the Rev. J. C. Pringle, Secretary of the Charity Organisation Society. He observes that "the houses of generals

in the Napoleonic wars had one candle after dark; we think one 16-candle-power lamp insufficient (? sufficient) for one room. If all artificial lighting were reduced to the real minimum there would not be much shortage of coal for the fleets or munition factories."

The *Gas World* very properly points out that the wax candle of that time was a most insufficient and unsatisfactory contrivance in comparison with modern illuminants, and that, in the present days, work is carried on at night to an extent undreamed of in the Napoleonic era. The determination of the minimum illumination required for certain processes is a matter for the expert, and cannot be casually decided by reference to past history. Certainly if artificial lighting were reduced to the order of illumination availing in the Napoleonic period, not only our offices but our factories—including those working on munitions—would find it almost impossible to carry on their work.

INTERNATIONAL GAS CONGRESS, SAN FRANCISCO.

READERS will be interested to note the coming International Gas Congress to be held at San Francisco in the week commencing September 27th.

The programme has not yet been definitely completed, but we note that among the proposed papers there will be several dealing with lighting. For example, there is to be a series of contributions on the following subjects:—

Street Lighting, by G. S. Barrows (Philadelphia).

Office and Street Lighting, by Messrs. Fog and Schofield (New York).

Semi-public Lighting, by T. J. Little (Philadelphia).

Buoy and Car Lighting, by G. E. Hulse (New York).

Industrial Lighting (name of author to be announced).

In addition there will be papers by Mr. W. D. Ryan, describing the lighting of the Exhibition, and Dr. Rosa on "The substitution of the heating value for the illuminating value in gas testing."

Of special interest is the announcement of a paper (subject not given) by Dr. Charles Carpenter of the South Metropolitan Gas Co.,

Established
1885.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.
Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES

Of Life Assurance, with Various Options

All Classes of Insurance Business Transacted

CHIEF OFFICES:

General Buildings, Perth, Scotland.
General Buildings, Aldwych, London.
General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, September, 1915.

	PAGE
Editorial L. GASTER	365
Factory Lighting, Report of the Departmental Committee on, Abstract	371
Factory Lighting, Report of the Departmental Committee on, Memorandum on ..	369
Illuminating Engineering, Short Notes on:—	
The Melting Point of Tungsten	391
Street Lighting in Chicago	391
Light and Superstition	392
Failure of Light during an Operation	392
A New Method of comparing Sources of Light which differ in Colour ..	393
The Firefly and Other Luminous Organisms	393
The Holophane "Ouvroir" in Paris	394
Topical and Industrial Section:—	
Railway Station Lighting with Half-Watt Lamps	395
High-Pressure Gas Lighting in an Engineering Workshop	396
The Monazite Sands of Travancore	396
Holophane Industrial Lighting	397
A New Type of Illuminated Sign	400
Economy in the Use of Light	402
The International Gas Congress in San Francisco	402
Insurance Coupon	403
A Portable Acetylene Lamp	404

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL

ACCIDENT FIRE AND LIFE

ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.
GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.
F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

A COMPACT TYPE OF PORTABLE ACETYLENE LAMP.

The illustration shows a new type of strong and portable acetylene lamp which has recently been brought out by the Thorn & Hoddle Acetylene Co. (London, S.W.). The model shown above has two jets with appropriate metal shades and can be obtained in two sizes using respectively one lb. and two lbs. of carbide. The two-burner lamp will

The charge is placed in the interior portion of the lamp which fits into the outer can containing the water. There is no tap and the burner is always full on, the consumption of gas being exactly compensated for by the inflow of water through a special valve. Once the lamp is set going it requires no further attention; if the light is no longer required



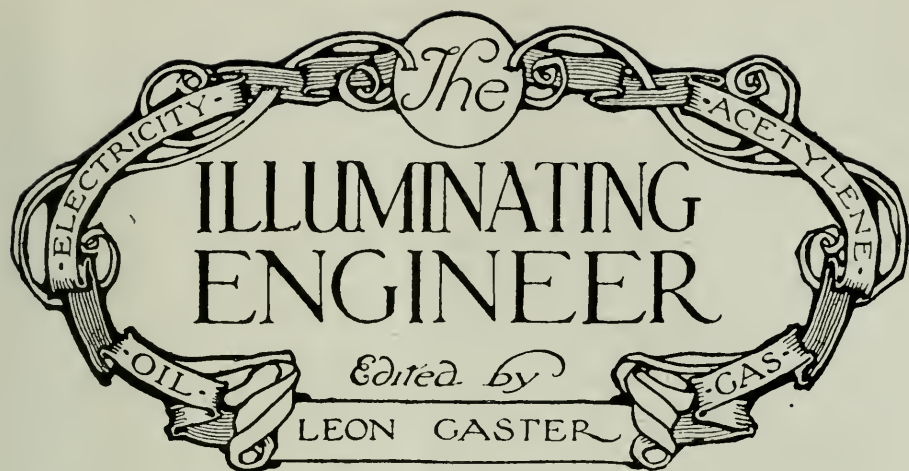
The "Incanto" self-contained Acetylene Lamp (Pattern H).

furnish light for about eight hours before being replenished. Smaller lamps having only a single burner are also available.

We have recently had the opportunity of inspecting these lamps. Their chief characteristic is simplicity and the strength of the parts. There is no manipulation and really nothing has to be done except to insert the requisite charge of carbide and to fill up with water, ordinary lump carbide being used.

all that is necessary is to raise the interior part of the lamp slightly and the evolution of gas ceases.

These lamps are considered particularly useful for emergency lighting by contractors and builders. They can be carried by hand in dark passages, stood up beside work or hung up on the wall or from the ceiling. Their strength and simplicity has, we understand, led to their being widely used for camps and military work.



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.

32, VICTORIA STREET, LONDON, S.W.

Tel. No. 5216 Victoria.

EDITORIAL.

The New Lighting Regulations.

To illuminating engineers the lighting conditions during the last year have been full of interest, and, properly studied, will supply much valuable information for future reference.

At the first meeting of the Illuminating Engineering Society last December it was pointed out that many of the changes are in the direction advocated by illuminating engineers on the simple grounds of economy and efficiency. The stimulus given to concealed lighting for shop-windows will certainly result in this proper method of illumination being more widely adopted after the war. Similarly, experience of the special shading of street lamps will probably induce the public and municipal authorities to appreciate the value of more subdued and evenly distributed street lighting in the future; and at the same time their experience of the inconvenience, not to say danger, of travelling in the streets with the present diminished illumination should bring home the folly of undue economy in this respect.

The enormous contrasts produced by illuminating parts of a street with needless brilliancy and leaving other regions in comparative darkness

have long been recognised as a drawback to modern street lighting. Inventors have, therefore, been busy with the problem of designing special lanterns which will both diminish glare and spread the light more evenly between the lamps. At the meeting of the Illuminating Engineering Society last December we ventured to point out that the very "patchy" illumination produced by the method of shading then adopted was most undesirable in main thoroughfares carrying heavy traffic; and that the transition from brightness to dense darkness was bound to be bewildering alike to drivers and pedestrians.

In the new lighting order of September 28th, we observe evidence of a desire for more uniform illumination. "Public lights . . . must be so extinguished, reduced, shaded or obscured as to break up all conspicuous groups and rows of lights and to produce as nearly as possible a uniform distribution of street lighting."

In order to achieve this result, without making too radical alterations in the structure of existing lanterns, it is proposed after blackening the upper part of the glass to frost or partly obscure the lower portions of lanterns, thus providing a light-scattering instead of a transparent surface. This will evidently have the effect of smoothing out the extreme irregularities arising from the system of shading hitherto adopted. It is expected that this change (together with the increased stringency as regards lighting of shop-fronts, &c.) will enable a considerable proportion of the public lamps to be lighted, and provision for turning on more lamps in a fog to be also made.

Illuminating engineers might be able to suggest more perfect methods of arriving at the desired results, but it will be conceded that the changes are at least in the right direction. It may, however, be justly said that such steps might quite well have been taken at the beginning of the war, and fuller use made of the services of those accustomed to study street-lighting problems.

Speaking generally, it cannot be said that the rule of thumb methods—the plan of learning purely by practical experience, and ignoring principles and information laboriously collected previous to the war—gives the best results. From the commencement we have urged the desirability of establishing some standard for the minimum illumination essential in the interest of safety in our streets. The data acquired by the Joint Committee on Street-lighting, for example, furnish some indication of the range of values existing in peace time and the order of variation which may be expected at different points in a street. The Report of the Departmental Committee on Lighting in Factories and Workshops, again, likewise furnishes an indication of the value of illumination that may fairly be required in the lighting of open spaces where work is carried on. An enquiry starting with this information as a basis would not only go far towards solving the present problem in a satisfactory manner but would yield information of the greatest possible value in the future. The only alternative, apparently, was to go on darkening the streets until a point was reached where the number of accidents and general inconvenience demonstrated that the permissible lower limit had at last been passed. This is the method of learning by bitter experience what might more easily be acquired by a little foresight and by making the best use of available information.

The new regulations regarding the lighting of shops and houses, tram-cars, railway stations, &c., have also given rise to much discussion in the press. In some respects they are more definite than those issued previously,

and in several of them we may perhaps trace the influence of the educational work carried on by the Illuminating Engineering Society. Everyone, of course, must admit the difficulty of framing in popular language precise and entirely definite rules bearing on the matter ; but at the same time it is obvious that many of the phrases are extremely vague. No one can say with conviction what is meant by "a subdued light," "the intensity reduced to a minimum," "the intensity sufficient for the safe conduct of business," "a light visible at a reasonable distance," or "a powerful lamp." Even if it were found impracticable to define these terms more precisely to the general public it is at least obvious that those whose duty it is to carry out the orders should have a clear and definite conception what is meant, and be able to explain this meaning.

These considerations are not disposed of by merely asserting that the public have loyally responded and are doing their best to comply with the regulations. Of course they do so. Everybody is anxious to do what is best for the country at the present moment. But that is no reason for lack of foresight in reducing the necessary sacrifices on their part to a minimum. A glance at the shops in almost any London street will show cases where, for want of a little guidance, shopkeepers are fulfilling the regulations, but in an obviously inconvenient and inefficient manner.

We do not suggest that the ordinary public should be confronted with elaborate engineering data or figures for "foot-candles," but we certainly do hope that those who have the planning of the present arrangements will keep a record of measurements of this kind and agree upon standards. Illuminating Engineers would be only too glad to co-operate with them in obtaining such data, and making them available for practicable application by lighting experts. Once determined, such data might be of service all over the country and eliminate the haphazard groping after principles and hand-to-mouth make-shift devices which prevail at present.

Above all, we think that members of the ordinary public, shopkeepers particularly, would benefit by a little friendly guidance, showing them not only how to comply with the requirements, but to do so in the most sensible way. It does not follow that all such explanations need be contained in the regulations. It might be practicable to indicate certain shops in each district which are passed as satisfactory, and are yet lighted in the best manner in the circumstances ; to issue photographs and descriptions of the methods employed ; and even to arrange for popular lectures advising the consumer what to do. We venture to think that there are many associated with the illuminating engineering movement who would be willing to assist in such matters, but naturally such steps could only be taken with the sanction and approval of the authorities.

It must be realised that these regulations affect the general public to a far greater extent than most ordinary legal enactments. They are not merely of academic interest to legal authorities, but modify profoundly the daily life of the nation. The British public is renowned for its law-abiding character, and the recent aircraft raids naturally predispose people to do all in their power to comply with orders made for their safety. But this acceptance of laws is conditional on their being clear and definite and incapable of widely different interpretation or possible misconstruction. If the regulations cannot be cast in a more definite form the next best thing would be for a central committee or court of appeal to be established, having at its disposal experts on lighting and able to deal with disputable cases in a thoroughly authoritative manner.

The New Postal Rates.

During the past month the new postal rates have naturally been the subject of much discussion in the press. To many journals the proposed abolition of halfpenny postage would be a serious matter, but it now appears that this cheap rate is to be retained.

The position of monthly and quarterly journals, to which this rate has not hitherto applied, is, however, still doubtful. It has long been a grievance that the publications of learned, technical and scientific societies should be charged at a higher rate than dailies and weeklies. Technical and scientific journals, and transactions of societies are rarely run at a great profit, but very often at considerable sacrifice, and during the war their difficulties have naturally increased. The subscriptions to societies in general allow no margin for additional postage, and it is quite impracticable to increase the subscriptions at the present time. Yet they are doing most valuable educational work which deserves the support and not discouragement by the State. Under the new postal rates they may apparently be even worse off in comparison with the dailies and weeklies.

One result of the increased postal charges may be that every possible effort will perforce be made to use other channels for distributing the journals. For example, several successive issues may be sent in one package in order to take advantage of the parcels rate (up to one pound for 4d.). Thus little (if any) gain in revenue can be looked for by the State. It is even suggested that the printing of some journals will be transferred to France or Holland, where the printing can be done cheaper even than here, and the journals posted thence to this country. The result of this would be that the Post Office would lose *all* their revenue from the carriage of these journals and British printers part of their trade.

The present war has surely demonstrated, above all else, the value of science and its applications, and we in this country will have to make great efforts to get abreast of our adversary in this respect. The recent establishment of a Council of Industrial Research may be taken as an indication of our intentions in this direction, and it seems extraordinary that in the present circumstances the scientific and technical journals, which constitute one of the chief channels for spreading abroad a knowledge of science and industrial processes, should be further handicapped in their difficult task.

We venture to suggest that at the present moment it is particularly desirable that a long-standing inequality should be removed, and that monthly technical and scientific publications, especially those which act as the official organs of societies, should be treated on the same basis as the daily and weekly papers. If this involves a loss to the Post Office would it not be practicable to place this loss to the account of Education?

The present Postmaster-General is known to be sympathetic towards measures designed to promote the advance of this country in scientific and technical matters. We venture to bring to his notice the hardship which the new postal charges will cause to many learned, scientific and technical societies throughout the country, and we hope that the suggestions made above will receive his sympathetic consideration.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(A Report presented by the Committee on Progress (Mr. F. E. Cady, *Chairman*, Mr. T. J. Little, Mr. L. B. Marks, Mr. T. W. Rolph), at the Ninth Annual Convention of the Illuminating Engineering Society, held in Washington, September 20th to 23rd, 1915; slightly abbreviated.)

DURING the past year there have occurred two events of striking significance, which may be symbolized by two flaming torches, one signaling destruction and conflagration, the other spreading its glow over construction, progress and enlightenment. One heralds animosity and antagonism, the other discloses amity and friendly relationship. The one is the sign of war, the other a proof of peace. In spite of the one progress has continued, in conjunction with the other the art of illumination has been extended. The European war repellant in its awful carnage has afforded grim and hitherto undreamt of possibilities in the use of light. The Panama-Pacific Exposition welcomes the whole world and stands as a magnificent example of the art of applied illumination.

Illuminating engineering is becoming recognized as a profession as attested by the employment of an illuminating engineer to take care of the lighting of the Exposition and by the announcement by the United States Government of examinations for the position of illuminating engineer in the office of the supervising architect at Washington.

The enormous demand for all sorts of

material required by the nations at war has necessitated night work in a large number of foreign factories. This has stimulated interest abroad in satisfactory and efficient systems of interior illumination.

It will be noted that the list of subjects covered by this year's report is slightly different from that shown in the report of last year. Some subjects are missing, others have been added. This is natural since progress is continually appearing in new directions.

Gas and Oil Lamps and Appurtenances.

Burners.—A very important development in incandescent gas lighting is the recent introduction of an upright unit fitted with three miniature mantles in soft form and made from artificial cellulose fibre. This type of lamp operates well over a reasonably fair range of gas pressure and qualities, is efficient and requires no enclosing draught-inducing cylinders. It can replace open-flame burners without glassware change on present fixtures and furnishes a means of obtaining semi-indirect or indirect illumination.

Several new types of inverted burners provided with inclined chute-like heat baffles to divert the products of combustion entirely away from the fixtures have been worked out in sizes giving approximately 100, 150 and 250 horizontal candlepower. These units are furnished with non-tarnishable, heat-resisting lacquer and are so constructed that the heat discharge vents are completely hidden. Being entirely of metal they can be finished to match the fixture on which they are to be used. The gas lamp designed to take advantage of the fact that the hottest part of the flame from a meeker or inverted Bunsen burner is in the neighbourhood of the small green inner cones and mentioned in last year's report has been in use in Germany¹ and proved the prediction of unusual sturdiness and long life.

An elaborate study of the room ventilating action of various types of gas burners has been made in England.² The results show that the ventilating efficiency is greatest for upright burners; that of the inverted burners, those giving a clear passage for the gases had the greatest ventilating efficiency; that the addition of deflectors intended to protect the fittings from the action of the gases reduced the ventilating efficiency by as much as 9 per cent. Experiments made in this country, however, show that when the stack is properly designed, higher efficiencies are obtained with deflectors due to a superheating of the mixture before burning. Globes with a very open base had no effect on the ventilating efficiency, but those with a constricted opening produced a reduction dependent on the area of that opening.

To produce the best results with the use of gas for lighting purposes, the character of the Bunsen flame used in conjunction with gas mantles must not change materially. In order to enable a manufacturer to ascertain how closely his service is maintaining constancy of burner conditions, a gauge has been developed.³ It consists of a small, slender upright Bunsen tube of exact design and carefully drilled orifice, mounted on the same base with a pressure gauge. A scale is placed

at the side of the Bunsen tube in order to check the length of the inner cone. Any variation of the cone length above or below a specified point can be easily noted. The gauge is not calibrated to indicate any specific quality of gas; but will show those changes only which will effect Bunsen burner service.

Despite the long life and high efficiency of the present day gas mantle efforts are still being made⁴ by inventors to either strengthen the structure or intensify the illuminating power by the application of some solution after the mantle has been purchased. Such efforts have not in the past been very successful.

Whether illuminating gas causes the fading of colours in fabrics has been made the subject of careful testing,⁵ experiments having been continued for a period of ninety days. It was found that the deterioration of colour either due to temperature, illumination, or the products of combustion arising from the use of gas lighting is of no practical importance compared with the effect of daylight.

Automatic Lighters.—The protected pilot tip so successfully applied to outdoor gas arc lamps has now been modified for use on indoor burners reducing the pilot flame outages to a minimum. A very simple electric gas cock for the distance control of gas burners has been produced. In Florence, Italy, a system of distance control for gas lighting⁶ has been in satisfactory use for the past three years. As a result of a recent successful test by military authorities, in which the city gas was shut off at a specified time and re-lighted after a predetermined period, it is expected that this system will shortly be employed in Italian frontier and coast towns. In general⁷ inventors are looking toward means for making distance lighting by pressure waves selective.

Artificial daylight units using gas as the illuminant⁸ have been developed and also units especially designed for photographic work which will be mentioned later.

Heating Value.—The use of the calorific standard for gas in place of the candle-

⁴ *Jour. of Gas Light.*, Feb. 23, 1915, p. 442.

⁵ *Ill. Eng. (Lond.)*, June, 1915, p. 292.

⁶ *Jour. of Gas Light.*, Mar. 2, 1915, p. 504.

⁷ *Jour. of Gas Light.*, May 18, 1915, p. 409.

⁸ *Light. Jour. (U.S.)*, Dec., 1915, p. 281.
Proc. Amer. Gas Inst., vol. IX, p. 886, 1914.

¹ *Jour. f. Gas*, July 25, 1914, p. 741.

² *Jour. of Gas Light.*, June 8, 1915, p. 573.

³ *Light. Jour. (U.S.)*, Dec., 1914, p. 82.

power standard is increasing in this country.⁹ In many localities both standards are still required, but it seems to be a quite general experience that if the gas is maintained at the right calorific value, the candlepower value will be satisfactory. At the 1914 convention of the American Gas Institute there was referred to the Board of Directors the question of adopting the Metropolitan No. 2 (Carpenter Argand) burner as the standard burner in the determination of gas candlepower. It has been suggested¹⁰ by the Bureau of Standards that "for those places where a candlepower specification is necessary in order to afford protection to users of open-flame lights, . . . an open-flame burner should be used in testing the gas candlepower." As the number of open-flame burners used in this country is relatively small the advisability of adopting this suggestion has been seriously questioned. The Bureau also suggests that the adoption of any standard burner might delay the present tendency toward the adoption of heating value standards.

Data have been given¹¹ of experiments which indicate that calorific value, specific gravity, and gas candlepower do not definitely specify a gas for commercial purposes. Gases which are identical in these properties may yet differ so in composition that the resultant flame temperatures will differ greatly and hence the performance of incandescent lighting appliances cannot be predetermined on this basis. It has been found, however, that heating values above 600 B.t.u. are not desirable for incandescent gas lighting.

A method has been devised¹² to enable a gas company to determine the candlepower of coal gas produced at night as well as by day. A holder, 3 ft. (0.90 m.) in diameter and 3 ft. high is used and the flow of gas into it is regulated so that it will just fill up during the night or during the day. Tests made on the candlepower of the gas collected in the holder agreed exactly with those made according to the "periodic method" in which readings are taken periodically

when the candlepower is at a maximum, at a minimum, and at the average.

Oil Lamps.—Of late years¹³ the use of high pressure oil lamps with incandescent mantles has considerably extended the employment of this illuminant. A Swedish type using Russian paraffin oil, consists of two essential parts, the lamp itself and the container for the oil. The latter is separated into two compartments, one containing the air compressed to 6 atmospheres by means of a small hand pump, the other holding about 2 gallons of oil. The pressure used in the container is maintained constant at $2\frac{1}{2}$ atmospheres by means of a reducing valve. The lamp is started by means of a little methylated spirit. A kerosene oil mantle lamp is now being used in this country which on recent tests showed a candlepower roughly twice, with a consumption of only half as much oil as any one of several circular-wick centre draft luminous flame lamps of the ordinary type.

Electric Incandescent Lamps.

Gas-filled Tungsten Lamps.—While the development of the tungsten filament electric incandescent lamp has been fairly rapid as compared with that of the carbon filament type, it would seem as if the progress each year was greater than that of the previous year and that salesmen would hardly have time to dispose of one product before an improved successor was available.

In last year's report¹⁴ reference was made to the sizes of non-vacuum gas-filled tungsten lamps then available, 400 being the lowest wattage for multiple burning. Now 100, 200 and 300-watt sizes are made.¹⁵ In May all sizes from 200 to 1,000 watts for circuits of 220 to 250 volts were¹⁶ put on the market. In England¹⁷ 60-watt lamps of this type were announced July 1st. In the 60-watt and 100-watt lamps argon gas is used instead of nitrogen. In Germany¹⁸ for 100 to 130-volt circuits, 40 and 60-watt

¹³ *Ill. Eng.* (Lond.), Jan., 1915, p. 37.

¹⁴ *TRANS. I. E. S.*, 9, 1914, p. 522.

¹⁵ Report of Lamp Committee Nat. Elec. Light Assn., June, 1915.

¹⁶ *Elec. Jour.*, June, 1915, p. 252.

¹⁷ *Elec. Times*, July 1, 1915, p. 1.

¹⁸ *Elek. Zeit.*, June 24, 1915, p. 319.

⁹ *Proc. Amer. Gas Inst.*, vol. IX, 1914, p. 367.

¹⁰ *Gas Inst. News*, March, 1915, p. 51.

¹¹ *Amer. Gas Light Journ.*, July 5, 1915, p. 1.

¹² *Amer. Gas Lt. Jour.*, Apr. 5, 1915, p. 219.

sizes, and for 200 to 250-volt circuits, 75 and 100-watt sizes were advertised at about the same time.

It should be recalled, however, that, while in lamps with filaments of large cross section, and, for multiple burning in general of high wattage, the advantage gained in being able to run the filaments at high temperatures and hence high lumens per watt is great compared to the loss in wattage due to convection and conduction in the gas, this advantage is greatly decreased, in the case of filaments of small cross-section such as those used for low wattages on multiple circuits, and hence the comparatively slow introduction of the latter.

There has been a marked improvement in the various mechanical features of the gas-filled tungsten lamp. Early lamps gave trouble due to the loosening of the bases because of the effect of the heat on the base cement. This has been remedied. A new solder has been devised to overcome the former melting of the solder at the junction of the leading-in wires and the base. Rusting or scaling of the leading-in wires has been eliminated by the use of a special coating. The distance between the filament and the stem seal has been increased, thus decreasing the temperature of the seal.

Another important step in advance lies in the standardising of the bulb,¹⁹ which now incorporates the good features of the round and straight-side types, previously used, together with the long neck containing a mica disc to keep the seal and base portion of the lamp cool. The distance from the light centre to the base has been made the same for the 300 to 500-watt sizes so that one type of fixture will do for any of these sizes. The use of the gas-filled lamp in special coloured bulbs for use in photography will be mentioned under another caption.

Before the advent of the gas-filled tungsten lamp the use in Germany of street lamps of the series type was limited. But²⁰ the great advantage of the series gas-filled unit was evident, and hence an effort has been made to overcome the features formerly considered objectionable. On alternating current circuits the

difficulty of low wattage was eliminated by the addition of a small transformer. On direct current circuits the troubles due to burn-outs in the series connections has been minimised by the use of carborundum, either in the form of sticks or powder. The carborundum is connected in parallel across each lamp and being cold takes practically no current as long as the lamp is lighted. But if a lamp goes out, the carborundum is heated by the passage of the line current and thereby causes a drop in voltage exactly equivalent to that formerly occurring in the lamp.

Physics.—There has been a continuation of the study of the physical properties of the gas-filled tungsten lamp. Thus it has been found that²¹ the spectral energy curves of a vacuum lamp at 1.2 watts per candle and a spiralled-filament gas-filled lamp operated at a colour match with it, superpose very closely throughout the infra-red spectrum. Tests have been made to determine the effect of winding the filament in the gas-filled lamp in the form of a spiral and the results indicated no marked difference in the quality of the light emanating from the straight and spiralled filaments of tungsten in an atmosphere of nitrogen. When the luminous efficiency (ratio of the "visible" to the total amount of radiation emitted) of these two types (straight and spiral-wound filaments in a nitrogen atmosphere) was practically the same, the candles-per-watt output was found to be 15 to 20 per cent. higher in the spiralled filament, owing to the lessening of convection losses. When the straight filament was operating at about 0.5 watt per candle and the spiralled filament was operated so that the outside surface of a turn was set to the same emissivity as that of the straight filament, the spectral energy curves of the two showed that the spiralled filament emitted about 7 per cent. more infra-red energy than the straight filament. Hence the luminous efficiency of the latter under the given conditions was 7 per cent. higher than the former.

Experiments have also been made²² showing that the so-called "stationary" film of gas about the filament of a gas-

¹⁹ *N. E. L. A. Bul.*, Apr., 1915, p. 246.

²⁰ *Zeit. f. El.*, Jan., 1915, p. 4.

²¹ *Elec. World*, Nov. 28, 1914, p. 1048.

²² *Elec. World*, Dec. 5, 1914, p. 1111.

filled lamp as a matter of fact does not cling to the filament, but moves upward along it.

Vacuum Tungsten Lamps.—Since last year's report there has been an increase in the efficiency of the vacuum tungsten lamp of from 7 to 10 per cent. in sizes below 150 watts. In July a sign lamp for multiple circuits, 105 to 125 volts was announced using 7.5 watts and giving 5 candlepower. This is the smallest wattage, standard lighting-circuit lamp yet manufactured. The practice of introducing chemicals to delay the discoloration of the bulb has been extended to include the 10, 15, and 20-watt sizes and has permitted the operation of all vacuum lamps at higher efficiencies. The spiral winding in a concentrated form is now used in the 25, 40, and 60-watt sizes,²³ in addition to those sizes in which it was previously used. These lamps use the same size bulbs and have the same average mean spherical efficiencies as the regular type of the same wattage, but have a somewhat shorter life. In Germany small lamps for signal purposes have been developed²⁴ which are designed to be burned in series with apparatus or circuits whose active or inactive operation it is desired to verify. These lamps are obtainable for a range of current consumption from 0.4 to 12 amperes.

A method has been recently patented, in which²⁵ the wires sealed into the glass stem of electric lamps are coated with a chemical salt, thereby making a better seal. The patent also covers the use of metal plated wire for use in such seals.

In line with the continued efforts towards standardisation there has been considered a plan²⁶ for settling upon two or three standard lamp voltages to be adopted as a basis for the manufacturer's output. This will simplify specifications.

The completeness with which the gas-filled street series lamps have superseded the vacuum type has resulted in the withdrawal of the street series vacuum lamps from the listed lamp schedules.

The tantalum lamp has now disappeared from the market and is being²⁷ rapidly

followed by the carbon lamp. The demand for gem lamps has fallen off to such an extent that it is difficult to retain the present limits of candlepower and wattage. In the case of miniature lamps, the tungsten filament has so completely replaced carbon that sales of tungsten comprise over 85 per cent. of the total of miniature lamps sold.

Rating.—It has become the almost universal custom to rate metal filament lamps in this country according to their watts input and apparently this method of rating has served to raise the prevailing standard of illumination. In England, however, a discussion before the British Illuminating Engineering Society²⁸ revealed the fact that this method of rating is by no means generally accepted as satisfactory. The preponderance of opinion seemed to be in favour of a return to some form of candlepower rating with a difference of opinion as to whether the unit should be the mean spherical candle or the lumen. In Germany also the subject has been considered at²⁹ a series of conferences held by the German Lamp Manufacturers who proposed the continuance of the voltage-wattage rating. The lighting committee of the German Association of Electrical Engineers discussed this proposal, but could come to no full agreement on the subject. A³⁰ representative from the Associations of Central Stations urged that it should be required by law to state the voltage, the upper and lower hemispherical candlepower, the total watts consumed and the watts-per-candle.

At the request of the³¹ Society of Motor Manufacturers and Traders the British Engineering Standards Committee has been investigating standard tungsten filament lamps of the vacuum type for automobiles. The question of whether such lamps should be rated at all in candlepower is receiving the attention of the committee and in the meantime they are rated in actual watts or nominal candlepower. Standard bulbs are defined and standard voltages. For headlights a standard distance of 30 mm. from the

²³ *Light. Jour.*, Mar., 1915, p. 65.

²⁴ *Elek. Zeit.*, Jan. 21, 1915, p. 27.

²⁵ *Elec. World*, Apr. 24, 1915, p. 1043.

²⁶ *N. E. L. A. Bul.*, Mar., 1915, p. 169.

²⁷ Lamp Com. Report, *loc. cit.*

²⁸ *Ill. Eng.* (Lond.), Apr., 1915, p. 167.

²⁹ *Elek. Zeit.*, May 13, 1915, p. 236.

³⁰ *Elek. Zeit.*, May 20, 1915, p. 248.

³¹ *Elec. Eng.* (Lond.), Feb. 18, 1915, p. 69.

contact plates to the centre of the filament is prescribed.

In Germany the gas-filled lamps were formerly widely advertised as "half-watt" lamps. Recently³² the largest manufacturers have made a determined effort to get away from this term, realising that it is as misleading, and hence a cause of trouble, as the old designation of "2,000 candlepower" was in the case of arc lamps.

Physics.—The disappearance of almost any kind of a gas introduced at low pressure into a bulb containing an incandescent tungsten filament has been investigated and it³³ has been found that there are four classes of reaction

involved. The filament is directly affected by the gas; or the gas reacts with the vapour given off by the filament; or the filament acts catalytically on the gas, producing a chemical change in the gas, but no permanent change in the filament; or the gas is chemically changed or made to react with the filament by means of electric discharges through the gas.

Studies have been made also on the³⁴ temperature distribution in the neighbourhood of a cooling junction of an electric incandescent lamp filament, and of the thermal conductivities of tungsten, tantalum, and carbon at incandescent temperatures.

(To be continued.)

³² *Zeit. f. El.*, Jan., 1915, p. 11.

³³ *Elec. World*, May 15, 1915, p. 1245.

³⁴ *Phys. Rev.*, vol. 4, 1914, pp. 524 and 535.

A SUGGESTED CODE OF LIGHTING FOR FACTORIES, MILLS AND OTHER WORK PLACES IN THE UNITED STATES.

(Presented at the Ninth Annual Convention of the Illuminating Engineering Society, U.S.A., held in Washington, September 20th to 24th, 1915; abbreviated.)

Article I. Daylight.—All buildings hereafter constructed must be provided with adequate window area. Awnings, window shades, diffusive or refractive glasses must be used for the purpose of improving daylight conditions or for the avoidance of excessive brilliancy wherever they are essential to these ends.

The windows, skylights, saw-tooth or other roof lighting constructions, are to be arranged with reasonably uniform bays, and the daylight openings shall be so designed and proportioned that at the darkest part of any work space, when normal exterior daylight conditions obtain, there shall be available at least a minimum intensity equal to three times the minimum intensities given in Article V. for artificial light.

(NOTE: The intensity requirements for daylight are higher than those for artificial light because the physical condition of the eye during the daytime is usually such as to require a higher intensity of natural light for satisfactory vision than is re-

quired at night under ordinary well designed artificial lighting systems.)

Article II. Old buildings at present constructed and not having adequate window area, must be provided with adequate artificial light according to the following articles, so as to supplement the natural light during normal daylight hours.

Article III. All buildings, whether old or hereafter constructed, must be provided during those hours of work when natural light is insufficient or not available, with adequate artificial light according to the following articles.

Article IV. Adequate intensity of the light must be provided for each class of work, both on a horizontal plane as well as on a vertical plane passing through the work, according to Article V. In all cases, however, glare on working surfaces is to be avoided as it tends to reduce the visual efficiency of the workmen and to increase the likelihood of accidents.

Article V. Artificial Light ; Intensity Required.—The average illumination intensity throughout any month actually measurable in foot-candles on a horizontal plane through the work is to conform to the following table. Uncertain cases which arise as to how to classify given manufacturing operations are to be left to the judgment of a lighting expert.

Class of Work.	Minimum foot-candle intensity.	Desirable foot-candle intensity.
Storage, passageways, stairways, and the like ..	0.25	0.25- 0.5
Rough manufacturing and other operations ..	1.25	1.25- 2.5
Fine manufacturing and other operations ..	3.50	3.5- 6.0
Special cases of fine work	—	10.0-15.0

Where operations are performed on the sides of the work in hand, they shall be classified according to this table, and if the illumination is furnished from an overhead system, it shall preferably be not less than 50 per cent. of the foregoing values, when measured on a vertical surface. If the illumination is furnished by an individual lamp or by lamps close to the work, the intensity shall conform to the minimum or desirable intensities required in the foregoing table.

(NOTE: As a guide to inspectors and others, it may be stated that with modern lamps roughly 1 candlepower per square foot produces an effective illumination of 3 foot-candles when the lamps are arranged according to the uniformly distributed overhead system, with mounting heights ranging from 12 to 16 ft. above the floor, and when the light is directed from said lamps to the work in an efficient manner. A rough idea may thus be secured of the candlepower per square foot necessary to conform to the foregoing table of intensities by taking one third of the intensity values given in the foregoing table.)

Thus for fine manufacturing and other operations, the minimum foot-candle intensity is 3.5, which is approximately equal to 1.2 candlepower per square foot. The use of a portable photometer or illuminometer, however, is recommended for the determination of existing systems and all uncertain cases are finally to be established by these instruments.

Article VI. Lamps and machinery jointly, are to be so arranged as to avoid

the casting of shadows over belts and other obstructions on important parts of the work, and the distribution of light from the lamps should be such as to avoid sharp contrasts of light and shade on the work.

Article VII. Inspection and regular maintenance of all lighting systems is required in spaces where work is being conducted, and in no case must the lighting devices, whether windows, lamps or auxiliaries such as globes and reflectors, be allowed to deteriorate, due either to dirt accumulations or to burned-out lamps, more than 20 per cent. below the minimum intensity values required by Article V.

Article VIII. Roadways, yards and places not usually frequented must either be provided by illumination during working hours when natural light is absent or partly absent, to make them safe against accident to employees traversing or engaged in such places, or a convenient control or controls must be placed at the entrance to basements, stock rooms, and the like, so that a person on entering can readily turn on the lamps beforehand.

Article IX. Stairways and passageways must be provided with lamps and reflectors or shades carefully located so as to shed their light generally over the entire space or spaces involved, and in sufficient quantity to make the stairways and passages safe against accident to employees traversing or engaged in such places. For intensities see Article V.

Article X. Each working space is preferably to be illuminated by lamps mounted overhead according to the system of general lighting, in preference to individual lighting. The overhead method of lighting, besides possessing many other advantages, also tends to reduce dark spots throughout the floor area, a feature usually objectionable with the use of individual lamps. This particular Article is not an absolute requirement, but a suggestion enforceable at the discretion of a lighting expert.

Article XI. Auxiliary lighting should be provided in all large work spaces, such lamps to be in operation simultaneously with the regular lighting system, so as to be available in case the latter should become temporarily deranged.

EXPLANATORY RULES.

EXPLANATORY NOTES.

The foregoing articles are supplemented by the following rules, which will aid in the observance of the requirements contained in the articles; tend to reduce eye trouble and accidents; and help in the securing of favourable results in planning lighting systems.

1. Lamps should be equipped with reflectors or shades for minimising glare and economising light. Bare lamps should not be used except in rare cases and then only when out of the line of vision.

2. As a general plan, mount the lamps high and out of the ordinary line of vision.

3. Although the types of reflectors and shades, and reflector and shade holders or fitters on the market are numerous, it is recommended that the holder or fitter, as well as the reflector or shade, be selected with reference to placing the light source at the proper point in the reflector or shade so as to eliminate glare, due to exposure of the light source, and also for the purpose of directing the light from the lamp effectively to the work, that is, for obtaining a distribution of light which meets the desired requirements.

4. Light thrown vertically downward is not the only important component of the resulting illumination. The sides of machinery, machine tools and work, as well as horizontal surfaces, often require good light.

5. Control few lamps in each group so that lamps not needed may be turned off conveniently.

6. Keep windows, lamps and reflectors clean, since large losses of light result from the accumulations of dust and dirt.

7. Provide a maintenance department if the shop is large enough to warrant it, so that all the items associated with the upkeep of the lighting system may be cared for systematically.

8. Keep ceilings and upper portions of walls a light colour for the purpose of rendering both natural and artificial lighting more efficient and better diffused. The lower portions of walls should be a colour which is restful to the eyes, preferably a medium tint, typified by the tint known as *factory green*, or a rather dark shade of yellow. Other medium tones are also available.

Section I. Daylight.—Adequate daylight facilities through large window areas together with light cheerful surroundings, are highly desirable and necessary features in every work place, and they should be supplied through the necessary channels not only from the humane standpoint, but also from the point of view of maximum plant efficiency.

Importance of Daylight.—The unusual attention to gas and electric lighting in factories, mills and other work places during the past few years; the perfection of various lamps and auxiliaries by means of which an improved quality and quantity of lighting effects are obtained; and the care which has been devoted to increasing the efficiency in various industrial operations;—all go to emphasise the many advantages and economies that result from suitable and adequate window space as a means for daylight in the proper quantities and in the right directions during those portions of the day when it is available.

Three Considerations.—Three important considerations of any lighting method are *sufficiency, continuity and diffusion*. With respect to the daylight illumination of interiors, *sufficiency* demands adequate window area; *continuity* requires (a) large enough window area for use on reasonably dark days, (b) means for reducing the illumination when excessive due to direct sunshine, and (c) supplementary lighting equipment for use on particularly dark days and especially towards the close of winter days; *diffusion* demands interior decorations that are as light in colour as practicable for ceilings and upper portions of walls, and of a dull or mat finish in order that the light which enters the windows or that which is produced by lamps, may not be absorbed and lost on the first object that it strikes, but that it may be returned by reflection and thus be used over and over again. Diffusion also requires that the various sources of light, whether windows, skylights or lamps, be well distributed about the space to be lighted. Light coloured surroundings as here suggested result in marked economy, but their main object is perhaps not so much economy as to obtain a result that will be satisfactory to the human eye.

Requirements.—The following requirements may now be listed for natural lighting:

1. The light should be adequate for each employee.

2. The windows should be so spaced and located that daylight conditions are fairly uniform over the working area.

3. The intensities of daylight should be such that artificial light will be required only during those portions of the day when it would naturally be considered necessary.

4. The windows should provide a quality of daylight which will avoid a glare due to the sun's rays and light from the sky shining directly into the eye, or where this does not prove to be the case at all parts of the day, window shades or other means should be available to make this end possible.

5. Ceilings and upper portions of walls should be maintained a light colour to increase the effectiveness of the lighting facilities from window areas. The lower portions of walls should be somewhat darker in tone to render the lighting restful for the eye. Factory green or other medium colours may be used to good effect.

Classification.—Means for natural lighting may be classed under three broad divisions as follows:

(a) That case in which the windows are located on the sides of the building or in the framework of saw-tooth construction, where diffused light from the sky reaches the work during a large portion of the day.

(b) That case in which windows are located overhead on a horizontal or nearly horizontal plane in the form of skylights, thus furnishing direct light from the sky during a large portion of the day.

(c) That case in which prismatic glass takes up the direct light from the sky and redirects it into the working space.

Method (a) is, of course, the most common of the three, and it may be noted that the saw-tooth or other roof lighting constructions have become very popular and result in an excellent quality and quantity of light for given window areas provided the size and location of windows are in accord with modern practice.

Increasing the Value of Floor Space.—Adequate and well distributed natural light means that certain portions of the

floor space which ordinarily would not be available for work, are converted into valuable manufacturing space. In a general way, therefore, the average factory, mill or other work place, if properly designed, should possess natural lighting facilities which produce the best practicable distribution of daylight illumination.

Wide Aisles.—With low ceilings and very wide aisles, workmen located at the central portion of the building must sometimes depend for their natural light on windows located at a considerable distance away from their working position. In these cases it may be impossible, in general, to depend altogether on daylight over an entire floor space, even at those times of the day when daylight conditions would be entirely adequate under other circumstances. This statement applies to side windows rather than to skylights or to saw-tooth construction. Fig. 1 illustrates this feature.

Varying Conditions.—In a case of this kind, employees located next to the windows are furnished with suitable daylight in the early morning and towards the latter part of the afternoon, the upper portions of the windows being particularly serviceable in lighting areas at some distance away from the windows. A southern exposure, however, results in such excessive light from the sky during the middle of the day, that heavy shades are nearly always pulled down so as to cover the entire window area. This plan makes it necessary to use artificial light throughout the larger part of the office during the brightest portion of the day, and reduces the daylight at those points where it would supposedly be the best, namely, near the windows. Here the location of the windows is a large factor in the excellence of the daylight conditions, but the manipulation of the shades is perhaps even more important. To avoid such a difficulty, adjustable translucent upper window shades with adjustable opaque lower shades might be employed.

Upper Portions of Windows.—It should be further noted in this illustration that the upper portions of the windows give a reduced illumination in proportion to their areas, to the floor space near them. In rooms of moderate size, therefore, the

windows should be placed as near the ceiling as practicable. When the sun shines through windows so located, the direct light must be reduced or diffused. This may be accomplished by the use of ribbed glass in ordinary factory and mill buildings, and in offices by the use of translucent sun shades or awnings.

Tempering the Light.—The light due to the sunshine on such shades and awnings will be as bright as ordinary skylight if the shade is well chosen, and the ribbed glass will be still brighter. If the windows are large, the illumination is likely to be too great near the windows as previously pointed out and it must be reduced. This should not be done, however, by pulling down an opaque shade over the top of the windows because the top portion of the window is the part that is particularly needed to give light to the interior of the room. The better scheme is to employ an opaque shade *which should be raised from the bottom of the window*. This will reduce the illumination near the window without affecting it over the interior of the room to any marked degree.

Bench Locations.—The usual arrangement of benches with respect to windows, so that the light received on the work may be most satisfactory, sets a certain limitation upon the possible arrangement of the work over the floor space, depending on the way the daylight is furnished to the floor area. This limitation can be eliminated almost completely in the case of artificial light through a uniform distribution of lamps overhead. This statement applies to those cases where natural light is transmitted through side windows, and includes a feature specially noticeable in buildings of more than one storey. In contrast, the work may be arranged almost independently of the natural light in buildings where the natural light is furnished by overhead windows or through the means of saw-tooth construction.

Window Glasses.—Both translucent and clear glass are employed for factory and mill windows. There is a slight reduction in the transmitted light through ordinary translucent wire glass, but it is often required by insurance regulations for a reduction in the fire risk where a given building is located in close proximity to

other buildings. Wire glass is also used quite generally with steel window frames, here being an added protection from the standpoint of fire risk. Wire glass may be obtained in clear form, but its expense in contrast to the translucent form is such as ordinarily to prohibit its use for industrial purposes.

Wire Glass.—Wire glass, also known as ribbed glass, should be used and is advocated for practically all factory and mill windows where prisms are not required. Wires of rather open mesh cause so little reduction in light as to warrant no mention of this feature. Special care should be taken to get such glass as is smooth both on the flat side and on the ribbed side to facilitate cleaning. Wire or ribbed glass gives better diffusion than plain glass.

Prism Glass.—Where the sky outside of the windows is obstructed by buildings, prism glass is recommended if the room is deep. Different kinds of prisms cannot be used to advantage interchangeably. The amount of prism glass required in any case depends much upon the surroundings and to obtain excellent results, of which such glass is capable, it must be used intelligently.

Skylights.—Skylights are sometimes installed in long narrow continuous strips in a sloping roof. The ribs of the ribbed glass are generally so arranged that it is convenient to make them at right angles to the length of the strips. The result is that the sunshine is diffused by the ribs over a narrow area parallel to the strip of skylight, thus lighting one part of the room much more brilliantly than the remainder. If the ribs are installed to run parallel to the strips, they will give a much more general distribution of the sunlight. In the foregoing, the word *strip* refers to the long belt of skylight and not to the individual sheet of glass. Ribbed glass in vertical windows should generally be placed with the ribs horizontal. They thus roughly fulfil some of the functions of prisms.

Dirt Accumulations.—While translucent wire or ribbed glass reduces the amount of light transmitted through the windows, the roughness of the outside surface of such glass often causes accumulations of dust and dirt, which are more to blame for the reduction of transmitted light in

some cases than the translucent nature of the glass itself. Remedies of this difficulty are to secure smooth glass and to resort to frequent cleaning.

Wire Glass as a Safeguard.—Wire glass for skylights is, of course, a practical necessity as a safeguard against accidents due to accidental breakage of the glass or due to objects falling on top of the glass.

Calculations for Natural Light.—In certain typical localities, the average brightness of the sky during business hours is about 250 candles per square foot. This is probably a fair average value for the entire United States. The lower or minimum value of sky brightness, excluding particularly stormy days, may be taken as about 100 candles per square foot. Allowing for a reduction of 25 per cent. for losses in the windows themselves, the brightness of the sky as seen through a window becomes equal to a minimum of say 75 candles per square foot in any directions from which the sky can be seen through the windows. This brightness value if multiplied by the part of the window area through which sky is visible from a given point in the work space gives the available candlepower through the window in question, and this candlepower is then divided by the square of the distance between the given point and the window to obtain the foot-candle intensity of the illumination at the given point.

Method illustrated.—To illustrate this method, consider a hall-way 40 ft. long, lighted by a window 5 ft. by 5 ft. at one end, with the sky visible from the darker end of the hall through the upper half of the window only. The illumination at the dark end of the hall will then be equal to:

$$5 \times 5 \times 0.5 \times \frac{75}{1600} = 0.58 \text{ foot-candles,}$$

under the assumed window brightness of 75 candles per square foot. The 1,600 in this calculation results from the square of 40 ft., the length of the hall, or in other words the distance from the point considered to the window; and the factor 0.5 takes into account the fact that the sky is visible through only one half of the window area from the point considered.

Checking the Intensity.—The intensity is not sufficient at this darkest part of the hall since the requirements of Article I of the Code proper call for three times the minimum values given in Article V, and the minimum value given in Article V for passage-ways is 0.25. Three times this value is 0.75 which is somewhat greater than the value found in this calculation. The window area must therefore be increased in size by about 50 per cent., or if this is impossible or impracticable, the hall-way must be provided with artificial light at those points where the natural light falls below the requirement.

Calculation for a Skylight.—As another illustration, assume that fine manufacturing work is to be performed under a skylight 20 ft. above the work. If the brightness is assumed to be 75 candles per square foot as before, the minimum intensity must be 3×3.5 foot-candles, that is, 10.5 foot-candles, based on the requirements of Article I of the Code. The window area must then equal:

$$10.5 \times \frac{400}{75} = 56 \text{ sq. ft.}$$

Part of Window Area to Consider.—It is important in estimating the illumination of any work room to consider only that portion of the window area through which clear sky is visible, provided the window is equipped with ordinary clear glass.

Sunshine Not Desirable.—In all the work of providing natural light, it should be kept in mind that direct sunshine in itself, from the illumination standpoint but irrespective of sanitary conditions, is not wanted. The idea that sunshine is the important item is a common but an erroneous impression. For example, in saw-tooth construction, the windows do not face the south to get all the sunshine possible, but they face the north to exclude the sunshine. Ordinary windows, on the other hand, face all directions because not enough light can be distributed to interiors from north windows alone. Windows on the other than north front admit sunshine to be sure, and this makes sun shades and awnings necessary to exclude the excessive brightness.

(To be continued.)

FIRST REPORT OF THE DEPARTMENTAL COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.

VOL. 2 MINUTES OF EVIDENCE.*

IN our last issue we published an abstract of the Report of the Departmental Committee. The Minutes of the Evidence are now also available. As the subject matter occupies nearly 200 pages it is only possible to give a very general idea of the contents of this volume. Readers will find in it a considerable amount of additional explanatory matter beyond that appearing in the Report itself, which is well worth careful study.

The matter has been arranged in a convenient form. There are four sections devoted respectively to:—(1) Witnesses examined, (2) A Summary of Evidence, (3) A Précis of Evidence, and (4) The Minutes of Evidence. The list of witnesses was given by us in the last issue of *THE ILLUMINATING ENGINEER*.† In the Summary of Evidence the various statements of witnesses are assembled together and classified under the following headings:—A. Accidents. B. White-washing of Walls and Roofs and Cleaning of Glass. C. Complaints. D. Damage to Eyesight and Health. E. Efficiency; Increased Output and Employers' Attitude towards Good Lighting. F. Criticism of any Existing Regulations. G. Glare. H. Existing Conditions and Customs in Special Processes. I. Shadows and Placing of Lights. J. Lighting-up

Time and Effect of Mixture of Natural and Artificial Light. K. Systems of Artificial Lighting and Methods followed in designing installations. L. Systems of Natural Lighting and Methods followed in designing installations. M. Numerical Data of Existing Illumination with Workmen's Criticism. N. Special Illumination Tests and Theories. O. Suggestions as to what the Committee should recommend, &c.

Following this classification we have the *Précis* of Evidence, which is in the nature of a summary of the remarks of each witness. Finally we have the verbatim account, the evidence as it was actually taken by the Committee.

Accidents.

Inspectors of factories agreed that bad lighting was generally regarded as a contributory cause of accidents, and various instances were mentioned. Thus, G. Bellhouse states that complaints of accidents due to bad lighting, referring chiefly to mill passages after dark, were made in 1911 by the United Textile Workers' Association. M. Williams referred to the danger from naphtha lamps, and H. J. Wilson comments on the frequency of accidents in the ship-building industries owing to the changing lighting conditions; a relatively high proportion of accidents occur by night. In iron and steel works, smoke and shadow sometimes lead to mishaps, and

* Blue Book (Cd. 8001). Obtainable from Eyre & Spottiswoode, Ltd., East Harding Street, London, E.C.

† *THE ILLUMINATING ENGINEER*, Sept., 1915, p. 379.

the same applies to shunting operations. A. P. Trotter considered that the prevention of accidents was the only ground on which regulations for illumination would be justified. In many cases a system of "beacon lighting" would suffice. The illumination of dangerous machinery was a proper subject for regulations.

Other evidence related to the desirability of ample window space and good artificial lighting in foundries.

Many witnesses attached importance to the periodical whitewashing of walls and cleaning of windows.

Instances of complaints of insufficient lighting in weaving rooms, foundries, &c., were mentioned by several witnesses. Mr. A. Stokes remarked that workpeople were very ready to complain if the light was not enough; he had also met with complaints on the score of glare. Mr. Harrison, however, thought that it was difficult to get evidence because employees are often reluctant to complain.

Damage to Eyesight and Health.

Several inspectors mentioned complaints of failing eyesight, headaches, &c., attributed to unsatisfactory illumination. In embroidery shops the percentage of operators wearing glasses is often high—in one instance as high as 44.4 per cent. H. Harrison mentioned a case in a coil-winding shop where the output in the evening was less than in the daytime, apparently owing to greater strain involved by artificial light. F. W. Edridge Green mentioned some instances of eyesight trouble and headaches attributed to glaring light. W. McDougall thought that the effect of glare would probably be to produce a neurasthenic condition

and nervous headaches. A complete investigation of this matter is desirable, but in order to be conclusive, the experiments should be carried out on a large scale.

Evidence from employers and operatives showed the importance of good lighting in certain operations, such as fine mending and "burling," tailory work, &c.

Efficiency and Increased Output.

Evidence showed a very general recognition among employers that good lighting is essential for increasing output and improving quality of work. Mr. T. E. Ritchie mentioned a case in his experience where the earnings of operatives went up 11 per cent., due to improved lighting, costing only 4 per cent. more. The accuracy of work was also improved. Indirect lighting was of special value in certain operations. Haydn T. Harrison remarked that it is necessary to ensure that increased illumination is not accompanied by glare. In old factories the illumination may sometimes be increased two to three times by the judicious planning of the installation, without increasing the cost.

The evidence both of employers and of operatives fully bears out the connection between lighting and output.

Criticism of Existing Regulations.

The chief criticisms of existing regulations were based on the fact that the inspectors have at present only vague powers in regard to lighting, and there are only a few specific trades in which requirements are at present made under the Factory Act.

Portions of the London Building Act were shown to cause difficulties in regard to the provision of natural illumination.

Glare and Inconvenient Shadows and Contrast.

J. A. Hine gives a list of processes in which glare is liable to occur owing to direct reflection of light from the material. H. C. Wheat mentioned that glare had the effect of lowering visual acuity and was apt to produce accidents due to the blinding effect. Clark and How, Trotter, Stokes and other witnesses referred to various methods of diminishing glare such as effective shading, placing the lamps out of the direct range of view, and avoiding the exposure of bright lights with a dark background. F. W. Edridge Green emphasised the desirability of avoiding undue contrast, and suggested a physiological explanation of its effect on the eye.

Many witnesses referred to the inconvenient effects of deep shadows, especially in trades where there is much moving machinery, or where stacks of material accumulate on the floor and tables. In sewing-machine factories it is particularly important that light should come from the right direction. H. Harrison pointed out that in foundries a certain amount of shadow was needed to enable the moulds to be seen. It was often desirable for local lights to be capable of adjustment so that workers could move them into the position best suited to the work they were doing.

A considerable section of the evidence deals with the amount of illumination suggested by various authorities as being required for certain trades. Witnesses also described the way in which the lighting installations are designed.

Evidence is also given as to the need for a recognised standard, and instances are quoted of many industrial operations where the illumination afforded in various

factories for identical processes varies within considerable limits.

Suggested Future Requirements.

The most important section of the Evidence is that containing suggestions for procedure in order to specify adequate lighting.

G. Bellhouse (Home Office, Factory Dept.) considered that there should be no difficulty about requiring adequate illumination in general terms, and it should be possible to formulate definite standards after suitable inquiry. The same view is expressed by other witnesses, but it is pointed out as desirable that "adequate lighting" should be defined in clear terms.

A. Stokes expressed the opinion that a low standard of general illumination would be acceptable, but care should be taken that manufacturers did not assume that this was the correct illumination to provide. J. S. Dow did not consider that it would be safe, in the present state of knowledge, to specify rigidly the illumination for various purposes. It might be possible to have a general standard, but the light required for various processes could only be determined as a result of systematic inquiries over several years. He agreed with other witnesses that any standard should be in terms of illumination. In regard to photometric measurements of illumination he thought an accuracy of ± 10 per cent. might be expected: this figure was also suggested by Mr. A. P. Trotter.

Several architects and surveyors expressed the opinion that it would be difficult to frame general regulations on natural illumination owing to the large number of exceptions that would have to be made.

THE NEW LIGHTING REGULATIONS.

IN an Order by the Home Secretary, dated September 28th, more stringent regulations for the screening of lights in dwelling-houses and railway carriages are to be enforced. These regulations have been the subject of much discussion in the technical press. The following are the chief provisions contained in the Order:—

In pursuance of the powers conferred on me by Regulation 11 of the Defence of the Realm (Consolidation) Regulations, 1914, I hereby make the following Order:—

STREET LIGHTING.

(1) Public lights in streets and squares, on bridges, and in all other public places must be so extinguished, reduced, shaded, or obscured as to break up all conspicuous groups and rows of lights and to produce as nearly as possible a uniform distribution of street lighting; and any instructions given for this purpose by the Commissioners of Police of the Metropolis and of the City of London in their respective jurisdictions must be observed.

(2) Sky signs, illuminated fascias, illuminated lettering, and outside lights of all descriptions used for advertising or for the illumination of shop fronts must be extinguished.

SHOPS AND HOUSES.

(3) The intensity of the inside lighting of shops and shop fronts must be reduced so that no more than a subdued light is cast in any direction outside the premises. All sources of light must be so screened as to cut off all direct light from windows and doors.

(4) Bright lights in hotels, flats, dwelling houses, and premises of all descriptions not coming under the other provisions of this Order must be shaded or windows screened, so that no bright light is cast in any direction outside.

(5) All large lighted roof areas must be covered over or the lighting intensity reduced to a minimum.

(6) The lighting of railway stations, sidings, and goods yards must be reduced to the intensity sufficient for the safe conduct of business there. The upper half of the globes of all bright lights must be shaded or painted over.

RAILWAY LIGHTS, &c.

(7) Passengers in railway carriages which are provided with blinds must keep the blinds lowered so as to cover the windows. The blinds may be lifted in case of necessity when the train is at a standstill at a station, but if lifted they must be lowered again before the train starts.

(8) Lights along any water front must be masked to prevent as far as practicable the reflection of the light upon the water.

(9) The aggregation of flares in street markets is prohibited, but properly screened lights of moderate power may be used.

MOTOR AND OTHER VEHICLES.

(10) The lights of trams and omnibuses must not be more than is sufficient to enable fares to be collected, and all lights except those required by paragraph 12 of this Order must be covered or extinguished while crossing bridges.

(11) The use of powerful lamps on motor and other vehicles is prohibited.

(12) Every person who shall cause or permit any vehicle during the period of half an hour after sunset and half an hour before sunrise, to be in any street, highway, or road to which the public have access, must provide such vehicle with a lamp or lamps in proper working order and so constructed and capable of being so attached as when lighted to display:—(a) to the front a white light visible for a reasonable distance. If only one lamp is provided for this purpose, it must be placed on the off or right side of the vehicle; (b) to the rear a red light visible for a reasonable distance. If only one light is provided for this purpose, it must be placed on the off or right side of the vehicle and in such a position that the red light is visible at a central point immediately behind the vehicle.

Every person driving or being in charge of any such vehicle during such period aforesaid must keep such lamp or lamps properly trimmed, lighted and attached.

For the purpose of this Order, the word "vehicle" shall include any bicycle, tricycle, or velocipede, and any vehicle drawn or propelled by hand.

(13) Subject to the foregoing provisions of this Order, all bright external lights and all aggregations of lights are prohibited, except in such circumstances and under such conditions as may be approved by the Commissioners of Police of the Metropolis and of the City of London in their respective jurisdictions.

EMERGENCY INSTRUCTIONS.

(14) In case of a sudden emergency, all instructions given by the Admiralty, as to the further reduction or extinction of lights, must be immediately obeyed.

This Order shall apply to the City of London and the whole of the Metropolitan Police District, and except as otherwise provided in paragraph 12, to the period from 6 p.m. till sunrise.

This Order shall take effect on October 1, 1915, and shall be in force until revoked or amended by further Order.

The Order of July 31, 1915, is hereby revoked as from October 1, 1915, without prejudice, however, to any proceedings in respect of contraventions of that Order.

JOHN SIMON.

One of His Majesty's Principal Secretaries of State.

Improvement in Street Illumination.

During the last few days, as a result of the Order summarised on the previous page, the darkening of the streets of London has been carried to such a stage that traffic by night was becoming a matter of considerable difficulty. Now several concessions are to be made, and an improvement in the lighting of the streets is taking place. It appears that the Metropolitan local authorities have received instructions that lamps in use must be darkened for two-thirds of their length and the remainder of the glass frosted over. The new arrangement appears to have in view an equalisation of the lighting. It is expected that about sixty per cent. of the lamps will be lighted

and others held in reserve for any emergency, for example in the case of fog. During the actual continuance of fog, flare lights will be permitted at dangerous points.

No doubt the plan of frosting the lower parts of the lamps will have the effect of spreading the light somewhat, so that the parts of the street most remote from the lamps will receive more illumination, and the severe contrast between the brightness immediately under lamps and the dense obscurity in between them will be lessened.

Another practice which is now being recommended is the whitening of the kerbs at street corners, refuges, &c., which should be of considerable help, both to drivers and to pedestrians.

AIDS TO TRAFFIC IN AMERICA.

IN the cities of the United States the question of guarding against traffic accidents in the streets is receiving special attention, and a number of ingenious devices are being tried. According to *Popular Mechanics* a special form of danger signal is now being put up on street corners in order to warn motorists of the approach of tramcars, in cases where the view is obstructed by buildings, fences, trees, &c. An iron post carries a special illuminated sign bearing the word "danger" in red letters. It also carries plates on which names of the roads meeting at the corners are indicated.

The most ingenious novelty, however, is an electrically controlled propeller-shaped device mounted at the extreme top of the post which automatically oscillates whenever a car is nearing the crossing. By this means the motorist receives warning in good time and can reduce his speed.

There is also another device intended for the convenience of men engaged in trimming are lamps about to be lowered to the pavement. This consists of a square sign carrying a red disc on a white

background and mounted on a tripod. Before commencing operations the trimmer places this sign underneath the lamp to be lowered, thus giving warning to approaching vehicles to avoid this spot. As soon as the work is finished the portable sign is removed and carried on to the next lamp.

MOTOR CAR RACES AT NIGHT.

A RECENT issue of *Popular Mechanics* contains an account of the artificial illumination of a motor car racing track in the United States, so as to enable high speed contests to take place during the night time. The course, one mile in length, was illuminated by a series of 185 double-burner lamps each capable of producing 1200 candle-power. These lamps were mounted on both sides of the track, and the illumination was assisted by arranging a white canvas wall 10 ft. high round the outside of the track.

In this way the racing cars were seen silhouetted against a white background. It is said that the contrast between the brilliantly illuminated track and the dark surroundings accentuated the impression of speed.

TESTING THE GLOSS OF PAPER AND OTHER MATERIALS.

AN interesting note on the above subject is contained in a Report recently presented by the British Association Committee on School-books and Eyesight.*

It is remarked that widespread efforts are being made to secure the fulfilment of the Committee's recommendations in regard to books for young children.

Among other points the quality of paper deserves consideration. The Report also deals with the problem of testing the gloss of papers, and describes an instrument originated by Mr. A. P. Trotter for this purpose. The history of this instrument is as follows:—

Dr. Louis Bell, in the course of a visit to the offices of THE ILLUMINATING ENGINEER in May, 1914, suggested the desirability of constructing an instrument by which the gloss of paper, particularly that of school books, could be measured. Accordingly, an interview with Mr. A. P. Trotter and Mr. Haydn T. Harrison, who were also interested in the subject, was arranged, and subsequently an experimental instrument was designed and was constructed in Mr. Haydn Harrison's laboratory. It was afterwards modified after some experimenting by Mr. Trotter, and was submitted to Mr. G. F. Daniell, Secretary of the Committee of the British Association on "The Influence of School-books upon Eyesight." A greatly improved instrument was made by Messrs. R. and J. Beck, and with this Mr. Trotter tested the paper of a number of journals and school books in June, 1914.

The scale of the instrument and the mode of describing the amount of gloss has been the subject of a good deal of consideration, and the final method adopted is due to Mr. G. F. Daniell.

It may be remembered that some time after this gloss-tester had been made, a description was published of an American instrument which depends on the use of polarised light.

We take the following account of the instrument from the Report kindly sent us by Mr. Daniell:—

Investigations have been made during the last two years in order to obtain an objective measurement of the gloss of paper, and the Committee is indebted to Mr. A. P. Trotter for designing a new form of gloss-tester, and for carrying out tests with books and writing-papers used in schools.

The Committee observes:—

(1) That glossiness of paper depends mainly on specular reflection, *i.e.*, reflection as from polished metals; such reflection is apt to interfere with binocular vision. The ideal surface for books would exhibit no specular reflection; all the reflected light would be scattered or diffuse reflection, equal in all directions and independent of the direction of the incident beam. Such absence of gloss is realisable in any fine white powder, such as magnesia, but not in printing papers. No harm to eyesight is, however, likely to accrue if the specular reflection is not excessive; hence the proportion of specular to diffuse reflection affords a suitable index of the glossiness of paper.

(2) That a large proportion of school-books and writing-papers are satisfactorily free from glare at angles of incidence not exceeding 45 degrees. In most of these satisfactory books the specular reflection does not exceed the diffuse reflection when the light is incident at 45 degrees, the paper being viewed from the direction of the corresponding specularly reflected rays.

(3) That when the specular reflection exceeds 56 per cent. (the diffuse reflection being then less than 44 per cent.), there is likely to be injurious glare. The risk is greater if the book is read in artificial light.

The Committee therefore hopes that publishers will select for school-books papers from which the specular reflection at 45 degrees does not exceed the diffuse

* School-books and Eyesight.—Report of the Committee, consisting of Dr. G. A. Auden (Chairman), Mr. G. F. Daniell (Secretary), Mr. C. H. Bothamley, Mr. W. D. Eggar, Professor R. A. Gregory, Mr. N. Bishop Harman, Mr. J. L. Holland, Dr. W. E. Sumpner, Mr. A. P. Trotter, and Mr. W. T. H. Walsh, appointed to inquire into the Influence of School-books upon Eyesight, presented at the British Association Meeting, Manchester, 1915.

reflection. Books in which the specular reflection exceeds 56 per cent. of the total reflection (specular *plus* diffuse) must be regarded as potentially injurious to eyesight.

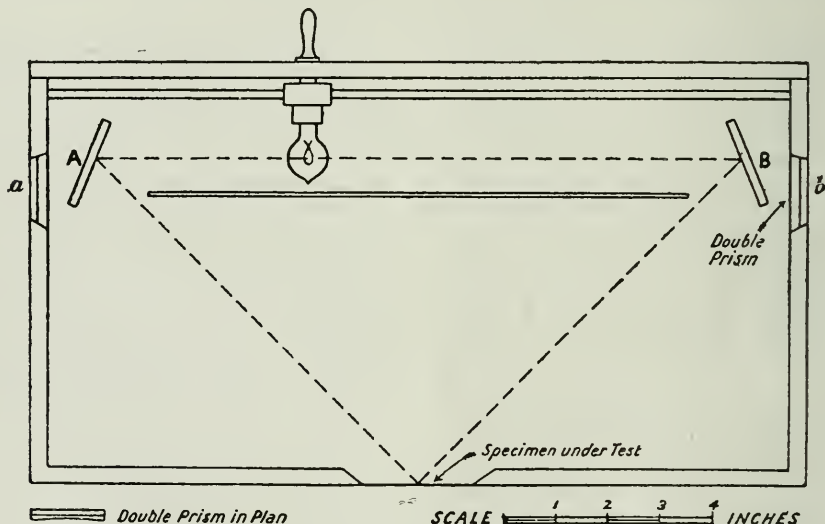
Writing-paper for school use should not give more than 54 per cent. specular reflection at 45 degrees, since young writers often look obliquely at the paper.

The Committee finds that coloured maps can be produced without extra expense or difficulty on paper conforming with the above rules. In some instances the effect of using suitable paper has been spoiled by the use of glaze in the colours or inks. The glossiness of paper is greatly influenced by the extent and particular method of calendering, and it is suggested that careful control of calendering will assist in obtaining the desired hardness and the even surface required, without introducing pernicious gloss.

and opposite angle of 45 degrees. The effect of the gloss is then a maximum. He can also observe it from a direction nearly parallel with the incident light. The effect of the gloss is then a minimum. The instrument provides means for making these two brightnesses equal, and for comparing them.

The instrument consists of a box 15 inches (300 mm.) long, 8 inches (203 mm.) wide, and of about the same height. In the bottom there is an opening $3\frac{3}{4}$ inches (85 mm.) by $1\frac{3}{4}$ inches (44 mm.). The box may be laid on the page of an open book, and the part of the paper seen through the opening becomes the specimen to be tested.

A small electric lamp carrying a pointer can be moved on a slide between two mirrors A and B. The lower part of the box is divided by a thin partition. Half of the specimen is illuminated from one mirror and half from the other. Two



GLOSS TESTING.

Mr. Trotter's description of his gloss-tester is subjoined at the request of the Committee, since the recommendations in this Report require that some standardising instrument should be available.

AN INSTRUMENT FOR TESTING THE GLOSS ON PAPER AND OTHER MATERIALS.

The principle of the method is to illuminate a specimen of the paper or other material by light falling on it at an angle of, say, 45 degrees. The observer can examine the brightness of the specimen from a direction making an equal

eye-tubes are arranged at *a* and *b* for observing the specimen, the view being obtained alongside the edge of a mirror. In each eye-tube there are a pair of acute-angled prisms edge to edge, by which the view of the thin partition may be cut out of view.

Let 100 be the total brightness, *d* the diffused brightness, and *s* the specular brightness. $100 = d + s$. The pointer attached to the lamp moves over a scale graduated from the formula

$$x = \{10 - \sqrt{100 - s}\}L / 2\{10 + \sqrt{100 - s}\}$$

where *x* is a length on the scale measured

from the middle point, s the specular brightness at 45° expressed as a percentage of the total brightness, and L the total length from the middle point of the opening through which the specimen is seen, to one mirror, across to the other mirror, and back to the middle point of the opening.

The whole instrument is bilaterally symmetrical, and, when the mirrors are properly adjusted, observations made from either end should give readings equidistant from the middle of the scale.

When a flattened layer of fine white powder, such as ordinary whitening, is tested, it is found practically free from gloss. In other words, the reflection is wholly diffusive, and there is no specular reflection. The brightness of the two halves is identical when the illumination is identical. The pointer is at the middle of the scale when the specimen is viewed from either end, and indicates $s=0$, the total brightness consisting only of diffused brightness d .

If a sheet of paper is tested in this way, and is observed through eye-tube a , the brightness of the half illuminated by reflection from the mirror B will be due to the sum of the diffused brightness d and of the partial specular brightness s . The brightness of the half illuminated by reflection from the mirror A is due to diffused brightness only. The lamp must therefore be brought nearer the mirror A to make the brightness of the two halves equal. If, when a balance has been obtained, the pointer stands at 66.6, this means that the brightness viewed from a direction nearly parallel to the direction of observation consists of brightness s due to specular reflection, which is twice the brightness d due to diffused reflection, and, therefore, 66.6 per cent. of the total brightness. As a check, an observation may be made through the other eye-tube.

When the specular brightness is more than 70 per cent. of the total brightness an imperfect image of the source of light begins to be formed. A bright glistening patch appears on one half of the specimen, and it becomes difficult to match this accurately with the brightness of pure diffused reflection. For this reason the method in its present form is not applicable to materials having a pronounced gloss.

In adjusting the instrument it is laid

on a mirror. The lamp is seen by reflection on one side of the partition, and when the lamp is moved it ought to appear to approach to or to recede from the eye in a straight line. The instrument should be used in a darkened room. The constancy of the candle-power of the lamp is immaterial; but it is advisable to use an evenly frosted bulb, as otherwise the asymmetry of the filament may introduce errors. The surface undergoing test should be quite flat.

A millimetre scale may be substituted for the percentage scale. The percentage of specular brightness at 45° , when the pointer is x millimetres from the middle of the scale, is then given by

$$s = 200Lx / (\frac{1}{2}L + x)^2.$$

Mr. Trotter has also placed at our disposal the results of a series of tests on the glossiness of paper used by various newspapers and periodicals. It is gratifying to see that the paper used in this journal is placed first on the list, as approaching nearest to a truly matt surface.

Various Journals.

	Percentage of Specular Reflection at 45°
The Illuminating Engineer, Official Organ of the Illuminating Engineering Society (London)	11
Programme 7th Convention III., Eng. Soc., Pittsburgh	23
Transactions Illum. Eng. Soc., New York Bureau of Standards. Technological Papers	33
Proc. Royal Society	41
National Physical Laboratory Report	41
Phil. Transactions Royal Society	44
Journal of Gas Lighting	44
Proceedings Inst. of Civil Engineers	44
Punch	47
Physical Review	49
Proc. Inst. of Mechanical Engineers	50
Proc. American Inst. Electrical Engineers	50
Philosophical Magazine	51
Morning Post	52
Engineering	58
Electrician	58
Times	61
Atti della Associazione Elctt. Italiana	61
La Science et la Vie	63
La Revue Electrique	64
Gas World	64
Electrical Review	67
Journal für Gasbeleuchtung	68
Electrical World	glazed
Zeit. f. Beleuchtungswesen	glazed

SEMI-INDIRECT LIGHTING IN A SMALL DRAWING-ROOM.

THE pictures on the opposite page illustrate the application of semi-indirect lighting in a modern drawing room. During the last few years this system of lighting has come to be considered very favourably for domestic lighting especially in cases where the occupant prefers a soft and restful effect. The impression produced in this case is very pleasing. The general illumination is derived from metal filament lamps in alabaster bowls and, as will be seen, the illumination is quite sufficient to enable all the surrounding objects to be seen without effort. A measurement (taken in a horizontal plane 1 metre above the floor) showed values of illumination from 0.75 in the corners of the room, up to 2—2.5 foot-candles immediately under the lamps. However, with a view to providing special local illumination and decorative effects, there is a liberal allowance of plugs round the room; some of which are utilised for the two candlesticks on the mantelpiece seen in Fig. 1, and for the small table lamp shown in the corner on the right of Fig. 2. These extra lights serve to give that slight additional local effect which is often desirable with indirect and semi-indirect lighting.

Another example of the utility of plugs for local lighting is provided by the arrangements made for illuminating the music on the piano. The necessary illumination (amounting to 3—5 foot-candles) is provided by a lamp mounted in a Holophane Uniflux reflector, and fixed on the wall to the left of the piano-forte. The outlines of this reflector can be seen on the extreme left. It completely screens the lamps from the players' eyes, and throws a strong and uniform light on the music.

The other illustration shows a small writing room where the main illumination is again furnished by a semi-indirect unit close to the ceiling. Here again any tendency to "flatness" has been counter-

acted by the use of a charming silk covered table lamp, ornamented with a Chinese pattern. The photograph will give a good idea of the appearance of this unit, but naturally cannot do justice to the colours of the silk which are also useful in giving a more lively effect. It may be mentioned that the pattern on this silk was specially designed and hand-painted, in order to harmonise with the pedestal containing the lamp.



Lumina Bureau Photo.

FIG. 3.—Small writing room. The general illumination is provided by the semi-indirect unit near the ceiling. The table is lighted by the charming silk portable lamp seen on the right.

The local illumination on the desk was measured and found to be about $3\frac{1}{2}$ foot-candles.

In all these rooms the avoidance of glare has been a special feature and they may serve as an example of domestic lighting which is subdued, and yet at the same time strikes the right note of cheerfulness and comfort.



Lumina Bureau Photo.

FIG. 1.—Showing semi-indirect fitting and candle-units on mantelpiece.



Lumina Bureau Photo.

FIG. 2.—Another view of the same room, showing the special device for illuminating the music at the piano.

Semi-indirect Lighting in a Drawing Room.

ILLUMINATING ENGINEERING AS A BRANCH OF TECHNICAL INSTRUCTION.

A PAPER on this subject was recently read before the Illuminating Engineering Society in the United States by Prof. C. E. Clewell, and a number of other professors, who have been responsible for the organisation of courses of instruction on this subject, took part in the discussion. Prof. Clewell mentioned that a committee of the Society has been engaged on a campaign to promote the study of illuminating engineering as a specific branch of instruction at colleges. In addition efforts are being made to introduce fuller instruction on illumination into the curriculum of architects, municipal engineers, and others who have to consider lighting in the course of their professional work.

Among the most interesting courses mentioned is that arranged by Prof. Scott at the Sheffield Scientific School of Yale University. It was felt that lectures by themselves do not suffice for instruction in this class of work. The students were also encouraged to study for themselves existing lighting installations and to become familiar with the practical applications of light by noting any defects and suggesting improvements. For example, during one week students were set to study the lighting of show windows throughout New Haven, and to report specifically on instances of good and bad lighting which had come under their observation. In another case the students were asked to draft a statement of the lighting in their study rooms, and to prepare plans, showing the arrangements of lamps, etc. Some of the comments quoted by Prof. Clewell show that this practice has been most useful in developing a critical faculty on the part of students. Discussions have also been organised at various times, when members of the Illuminating Engineering Society were invited to come down and address the students. At Pennsylvania University a special feature has been the course on Illumination for graduate engineers, in which the solution of various practical problems, assisted by measurements of illumination, has been systematically mapped out.

In the majority of cases lectures on illuminating engineering are regarded as a useful element in the course of instruction, and, although the methods vary, lighting now forms an integral part of the course of study of most colleges in the United States.

In the course of the discussion Mr. Norman Macbeth pointed out that in the year 1913 the sales of lighting equipment in the United States amounted to over \$65,000,000, and the sales of energy from central stations to over \$300,000,000. When, in addition, the money spent on gas and other methods of lighting is borne in mind, the opportunities of illuminating engineering and the need for systematic education in this subject are evident.

GAS LIGHTING IN A WOODWORKING SHOP.

In our August issue we gave examples of factory lighting by gas in the district of the South Metropolitan Gas Co., to whom we are also indebted for the particulars of the lighting of the workshop shown herewith.

Fig. 1 is a view of the carpenter's shop in Messrs. Patterson and Edwards, lighted by a series of low pressure burners in globes over the benches, where an illumination of 3.5—5 foot-candles was measured. The illumination in the gangway (measured 18 in. above floor) is given as 2.04 foot-candles.

In Fig. 2 we have the Assembling and Finishing Shop. On the benches here values ranging from 4.66—6.33 foot-candles were recorded, in the gangways 4.5 foot-candles.

These figures, like those given in the previous article, are probably typical of many workshops lighted by low pressure gas. The illumination provided is presumably quite sufficient for this kind of work, and agrees with that suggested by other authorities, while the values given for other parts of the room are well above that generally considered requisite in the interests of convenience and safety.



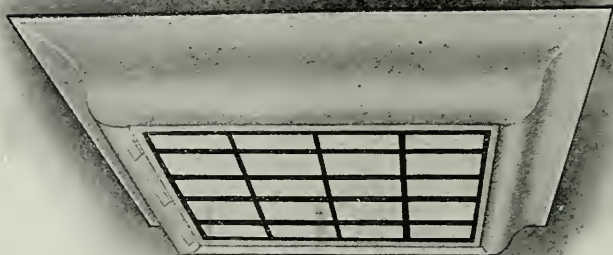
FIG. 1.—Carpenter's shop ; local low pressure units with shades over the benches.



FIG. 2.—Assembling and finishing shop ; low pressure lamps in globes over the benches.

Gas Lighting in a Woodworking Shop.

A NOVEL CEILING FITTING.



THE Beuttell "Sunburst" Fitting, shown above, is a decidedly ingenious device for imitating the "lantern lights," to which architects attach considerable importance in planning the access of daylight into buildings. A certain amount of overhead lighting is essential in almost all rooms, and it is also desirable that the light should come from an extended area. In these circumstances the rays do not strike the desks and tables at an unduly oblique angle, and the fact that the rays from a skylight come from a considerable luminous area helps to prevent inconvenient shadows.

Various attempts have been made to reproduce this effect artificially. By using indirect and semi-indirect methods the ceiling can be made into an extensive illumination, and soft shadows obtained. But it is more difficult to imitate the effect of transmitted light coming through a glass window. If proper arrangements are made at an early stage in the design of the building, apertures can be made in the ceiling and lamps concealed behind diffusing glass. In some installations in the United States (for example in the Pittsburgh Alleghany Memorial Building) this method has been used very extensively and with good results. But

it cannot be applied to an existing ceiling without extensive alterations.

The "Sunburst" fitting is contrived on a different plan. It consists in a specially shaped matt white surface, illuminated by concealed tubular lamps in reflectors on the Beuttell system. The illuminated surface thus becomes a source reflecting the rays of light into the room through an appropriate glass panel. Naturally a certain amount of light is absorbed in the process, but, it is stated, not more than would result from the necessary use of heavy diffusing glass with lamps above. The illustration shows a fitting of this kind, the tubular lamps being concealed by an appropriate metal moulding which can be shaped and painted to harmonise with the other features of the ceiling. The standard equipment for a fixture measuring 3 feet 6 inches along each edge, with a leaded glass panel $2\frac{1}{2}$ feet square, is four 60-watt tubular lamps, each fitted with a suitable strip reflector.

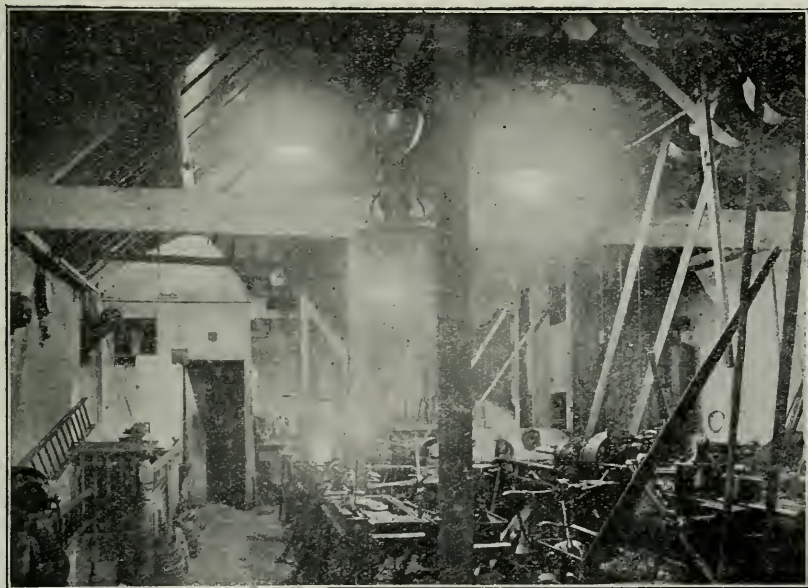
The same principle has been applied to signs, the surface illuminated by tubular lamps and strip reflectors replacing the usual distribution of tungsten lamps behind white glass. The illumination appears to be much more even and the number of lamps required to produce a given illumination is considerably reduced

TOPICAL AND INDUSTRIAL SECTION.

— • • • —

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]



Lumina Bureau Photo.

Incandescent Oil Lighting in a Workshop.

This workshop is lighted by Blanchard lamps, and illustrates the ease with which emergency lighting can be obtained with this system. The lamps are quite self-contained and portable, and are easily hung from walls and rafters wherever they are needed.

WANTED—EXPERT IN MANUFACTURE OF METAL FILAMENT LAMPS.

Expert in manufacture of metal filament lamps (half and one watt) wanted to organise and develop factory in London. Adequate remuneration will be paid to man having necessary qualifications. State in confidence full particulars of age, experience, salary required. Inquiries should be addressed—A.B., c/o The Illuminating Engineer, 32, Victoria Street, London, S.W.

GLASS-MAKING AT THE EDISWAN WORKS.

WE were recently afforded an opportunity of visiting the Glass Works of the Edison & Swan United Electric Light Co., Ltd. at Ponders End, where, during the last year, considerable progress has been made, two new 10-pot glass-houses having been built. We were given to understand that the firm has always been able to cope with the demands for glass bulbs, and can now, with their increased plant, continue to make the whole of their requirements of bulbs, tube, etc., which is required for the making of an electric lamp.

These glass-houses are centrally heated by solid fuel: the pots or crucibles for containing the charge for making the glass are fitted into the furnace at intervals, according to the capacity of the furnaces, those at Ediswan being built, two to contain 10 pots, one 8 pots and the other 6 pots or crucibles.

The making of these pots requires considerable skill, and can only be undertaken by one who has served a good apprenticeship to the trade, as the whole process depends on the operator knowing the quality and also when the clay is in the right condition or properly tempered for the work.

After the pot is completed it wants at least a year to dry and get seasoned before it is ready for use. This part of the business the Ediswan Company have certainly arranged for, as we were shown a room which has been specially built for pot-making. In Fig. 1 are shown the men turning and treading the clay with their bare feet, so as to temper it ready for the pot-maker. Fig. 2 shows the pots in course of construction, while Fig. 3 shows a complete room full of finished pots, 120 in all.

It will readily be understood that the dimensions of each must be as nearly accurate as possible, and that the moulding to the correct shape requires considerable skill and patience.

During our visit we were also fortunate in seeing, what in the glass trade is called "pot setting," or the putting of a new crucible into the furnace. The new pot has in the first place to be put into the pot arch, or subsidiary furnace, to be gradually brought up to the heat of the furnace, or as near to that as possible. This takes at least a week as, should there be any undue haste, the pots would break in the bringing up; very great care must therefore be bestowed on this part of the business.

When all is ready the brickwork surrounding the old pot in the furnace is knocked down and cleared away; then the old pot is withdrawn from the furnace on a long forked carriage, and run out of the shop. Next, any repairs round the fireplace or eye of the furnace have to be made good by the insertion of large pieces of wet clay and fire brick, which are patted down level by the aid of a long paddle or trowel, after which the furnace is ready to receive the new pot. This is brought from the pot arch on the forked carriage, put carefully into position, and bricked up in front and over the top to make good what was knocked down to take the old pot out.



FIG. 3.—Room full of completed pots, 120 in number.

As the whole of this operation has to be done with the furnace going at its highest heat it will be easily understood that it is a very delicate operation. Should any flaw occur, the new pot may



FIG. 1.—Men treading down the clay with bare feet, preparatory to moulding the pots.

be broken, and there is also great danger, if the operation is prolonged, of the furnace getting too cold and the whole of the pots in the furnace breaking. When one remembers the great heat which is radiated from the furnace and endured by the men, the speed at which the whole operation is carried out is remarkable.

After about twelve hours in the furnace

the pot is ready to be glazed and cleaned out with a large ladle, when it is ready to receive its first charge, and in 48 hours from the time of setting the glass-blowers are making glass bulbs from the contents of the next pot.

In addition to the glass-making the firm are making the caps for the lamps on the premises, so that the whole lamp is manufactured in the one factory.



FIG. 2.—Showing pots in course of construction.

G.E.C. FITTINGS ACCESSORIES FOR ELECTRIC LIGHT.

IN our last issue we referred to the new Fittings Accessories catalogue of the **General Electric Co., Ltd.** On the opposite page we now reproduce a few of the most interesting units therein. These have been selected as dealing with two sections of lighting which are naturally interesting the public very much just now—the illumination of streets and show-windows.

The first two illustrations (Figs. 1 and 2) show new designs for street-lighting units which are specially contrived to meet the difficult requirement of providing even illumination between the lamp posts. The lantern shown in Fig. 1 utilises the new Holophane unit, which has been described before in these columns, and is specially intended for street-lighting. The prisms are designed with a view to producing the correct polar curve, and at the same time avoiding excessive glare. A special point is the ingenious juxtaposition of two separate glass envelopes by which smooth inner and outer surfaces are obtained, thus preventing inconvenient lodgments of dust and grit, such as are apt to occur in the open, and facilitating cleaning.

The second illustration shows the use of a reflecting cone in the interior of the globe, which likewise serves the purpose of accentuating the light in those regions of the street most remote from the lamp, and evening up the illumination on the pavement.

Figs. 3 and 4 show types of mirror-glass reflectors, which are invaluable at the present time for window lighting. The aim in both cases is to illuminate the goods by *concealed light*, thus enabling the consumer to meet more easily the requirements of the authorities in war time, and at the same time to get the best results from the illuminating engineering standpoint. In view of the increasing strictness of the regulations such devices deserve attention.

ILLUSTRATED BOOKLET OF HOLOPHANE INSTALLATIONS.

Holophane Limited have just recently issued a new Illustrated Handbook, comprising a series of reproductions of photographs of actual lighting installations made with the Holophane System of Illumination.

The book is divided into sections according to the class of building dealt with. For instance, there are separate sections relating to Churches, Public Buildings, Railways, Private Houses, Banks and Offices, Industrial Lighting, &c.

The object of the book is to show that the Holophane System of Illumination is capable of being adapted to any class of building or style of architecture, and there is no better method of doing this than by illustrating photographs of actual installations.

Although Holophane Glassware is often chosen on account of its scientific design and because of the economies it achieves, the appearance of the units is also an important consideration. In the lighting of the fine interiors it is necessary to select fittings and glassware which harmonise with the general scheme of decoration, and have a dignified and impressive appearance. Its qualities in this respect have led to Holophane Glassware being widely used in many important public buildings and interiors of architectural distinction. We need hardly add that the illustrated book is one which electrical contractors and architects would find very useful for reference purposes, as well as being highly instructive.

— o —

PODMORE SPECIALITIES.

WE have before us a reprint of a booklet issued by **A. E. Podmore & Co., Ltd.** (Charles Street, Hatton Garden, London), describing various gas units which were exhibited at the National Gas Exhibition at Shepherd's Bush in 1913.

The list includes both indoor and outdoor units, a special feature being the strong and durable construction of the lamps and the complete means of adjustment provided. We notice particularly a 3-light fitting using an opal reflector which appears well suited for school work—a branch of lighting of which this firm have made a speciality.

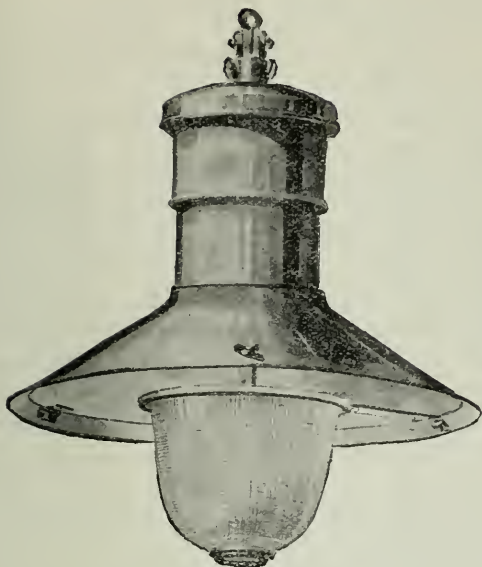


FIG. 1.—The "County" Lantern, containing special Holophane unit for half-watt lamps, designed to give more uniform street illumination.

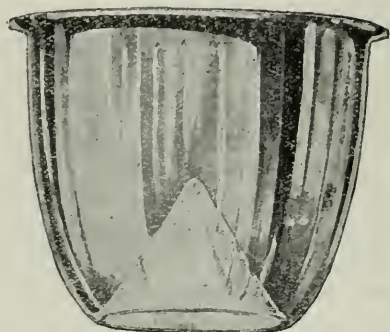


FIG. 2.—Another Street Lighting Globe designed to give even illumination for street lighting. The opal glass cone secn at the base of the globes serves the purpose of deflecting rays to the parts of the street most remote from the lamp.

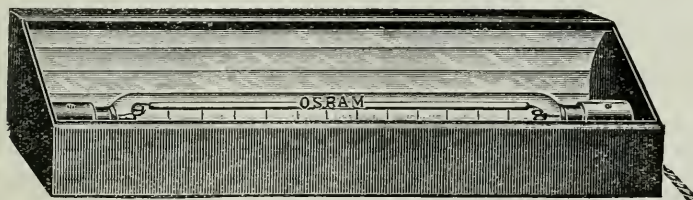


FIG. 3.—Giant Iron-cased Striplite Reflector.

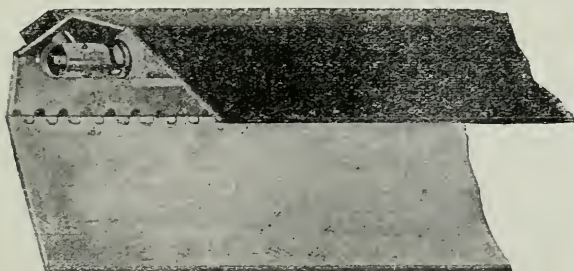


FIG. 4.—Special Shop-window Reflector concealing the lamp from the eyes of people in the street and strongly illuminating the goods.

Some G.E.C. Fittings Accessories.

HEATING, LIGHTING, AND COOKING EXHIBITION.

DURING the week from October 4th—9th an interesting Exhibition dealing with heating, lighting, and cooking was organised in London by the Institute of Hygiene.

The rooms of the Institute were fitted up in an agreeable manner, and demonstrations of Cooking, Bread and Cake Making, &c., took place each day throughout the week. An item of considerable topical interest was the instruction given in preparing English, Scotch and Irish, French, Russian, Italian, and Belgian Dishes, which proved most attractive to numerous lady visitors. Gas cookers and heaters of various kinds were also shown in operation.

Some highly educational cinematograph films were also shown, most of them

dealing with hygienic and sanitary matters. Lectures were delivered by:—

Mrs. Cloudesley Brereton ("Domestic Heating").

Dr. R. King Brown ("Heating and Health").

Mr. Leon Gaster ("The Use and Abuse of Light").

Mr. Herman Senn ("Economy in Cooking").

Mr. Gaster's lecture dealt in a popular manner with the fundamentals of principles of good lighting, special reference being made to the need for good illumination in the home in the interests of the children, the lighting of schoolrooms, and the work recently carried out by the Departmental Committee on the Lighting of Factories and Workshops.

The lighting of the rooms was carried out by a series of up-to-date Holophane gas units, with distance control.

THE CHANGE IN IDEALS FOR VENTILATION.

AN instructive article on this subject was recently contributed to the August issue of *School Hygiene* by Dr. James Kerr, who summarised much of the careful research work that has been done on this subject during recent years.

As ventilation must so often be considered simultaneously with lighting, we make no apology for referring our readers to this matter.

Among the most important points emphasised by Dr. Kerr, we may mention the recognition that the carbon dioxide and other small impurities in the air are of little consequence in comparison with the organic matters given off in respiration. Dr. Kerr also points out that in planning school buildings, heating and ventilation should be considered as separate subjects, and that there is frequently confusion between the two. In particular, he lays stress on the desirability of heating by radiation, remarking that "the chief part of the heat distribution in the rooms of the building should be by other means than the air."

Established 1885.		Established 1885.
By Appointment.		
GENERAL		
Accident Fire and Life Assurance Corporation, Limited		
Assets Exceed - £2,500,000. Claims Paid Over £7,000,000.		
<u>SPECIAL FEATURES:</u>		
ACCIDENT INSURANCE Liberal Benefits and Conditions. Low Premiums.		
FREE FIRE INSURANCE EVERY SIXTH YEAR TO PRIVATE PROPERTY OWNERS AND HOUSEHOLDERS.		
THREE POPULAR POLICIES Of Life Assurance, with Various Options		
All Classes of Insurance Business Transacted		
CHIEF OFFICES: General Buildings, Perth, Scotland. General Buildings, Aldwych, London. General Manager - F. NORIE-MILLER, J.P. NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.		

INDEX, October, 1915.

	PAGE
Editorial L. GASTER	405
Factories and Mills, A Code of Lighting for	414
Factory Lighting, Minutes of Evidence before Departmental Committee on ..	420
Gloss on Paper, Testing the	425
Illuminating Engineering, A Year's Progress in	409
Illuminating Engineering as a Branch of Technical Instruction	430
Lighting Regulations	423
Semi-Indirect Lighting in a Small Drawing Room	428
Wood Workshop, Gas Lighting in a	430
Topical and Industrial Section:—	
"Sunburst" Fitting	432
Incandescent Oil Lighting in a Workshop	433
Glass Making at the Ediswan Works	434
G.E.C. Fittings Accessories—New Holophane Booklet—Podmore Specialities ..	436
Heating, Lighting and Cooking Exhibition—Ventilation	438
Insurance Coupon	439
B.T.H. Leaflet	440

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL ACCIDENT FIRE AND LIFE ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.
GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.

F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within
seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

A NEW B.T.H. LAMP LIST.

THOSE of our readers who have not seen the latest Mazda Lamp List are advised to apply to Mazda House, 77, Upper Thames Street, E.C., for a copy. The cover is a good example of fine colouring and the design is pleasing, as will be seen by the reproduction shown, which, however, naturally gives no idea of the actual colour scheme in blue, yellow, and orange.

The information pages of this list are well planned, and the illustration of the characteristic light distribution of Mazda

pamphlet describing the "Revo" electric fires. These radiators are arranged in a very compact form. A special point is the use of incandescent wire coils in free air, and wound on refractory material.

Among the special advantages claimed for the heater are the rapidity with which heat is generated (no time-lag), and the special design which diminishes to a minimum the heat radiated in a rearward direction and projects the rays forward. In addition, shock-absorbing apparatus prevents the elements of the heater being broken in transit.



Lamps is an innovation in lists of this kind. All the Standard Mazda Lamps are illustrated and priced, and a two-page sheet, dealing with Mazda Half-Watt Lamps, is pasted on at the end.

"REVO" ELECTRIC FIRES.

THE Cable Accessories Co., Ltd. (Britannia Works, Tividale, Tipton) sends us a

"SIMPLEX" SPECIALITIES.

THIS name includes a variety of patent devices of interest to engineers, shipbuilders, shipowners, &c. (valve re-seaters, adjustable steel wire brushes, tube scrapers, condenser tube scaling machines), which are manufactured by Bromell Patents Co., Ltd. (Glasgow).



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

An American "Code on Factory Lighting."

Almost simultaneously with the issue of the Report of the Home Office Departmental Committee on Lighting in Factories and Workshops in this country a "Code on Factory Lighting," prepared by a committee of the American Illuminating Engineering Society, has appeared. This committee has been considering the legislation of the chief States in America bearing on lighting, and the Code summarises the chief requirements of modern industrial illumination.

The issue of this Code, at the same time as the Departmental Report, is a striking recognition of the necessity for a full investigation of the subject being carried out independently in the two countries. It is also interesting to note that the Code is in general agreement with the Departmental Report, though naturally a somewhat different type of publication. It is the result of consultation on the part of a committee of experts, but is not an official Government publication preparatory to legislation.

There is therefore not the same necessity for giving detailed explanations of the technical terms used and data presented. Among the advantages of good illumination are mentioned: "Reduction of accidents, Greater accuracy of workmanship, Increased production for the same labour cost, Less eye-strain, Better working and living conditions, Greater contentment of workmen, More order and neatness in the plant, Supervision of men made easier."

We are reproducing this Code *in extenso*, and portions of it have already appeared in our last and present numbers. The values suggested for the desirable illumination are of particular interest in view of their general agreement with those specified in the Report. It should be noted that in several cases the illumination is regarded as necessary not only for safety but for enabling work to be done; the values are therefore naturally higher than those required from the standpoint of convenience and safety only. Moreover, while the values suggested in the Report are put forward as practical *legal* minima those given in the Code are presumably free from this limitation, and it is therefore possible to aim at higher values, such as an enterprising modern manufacturer would naturally desire to provide.

The Code deals with both natural and artificial illumination and makes various practical suggestions as to the best utilisation of floor-space and the location of benches with respect to the windows. Attention is drawn to the value of the upper portions of windows, on which their lighting efficiency mainly depends, and it is suggested that with a view to using this part as fully as possible blinds should be constructed to be drawn *upwards*. The importance of light walls and ceilings, for the distribution both of daylight and artificial light, also receives recognition. By artificial light, it is well known, the diffusion of rays by such light-tinted surfaces does much to diminish inconvenient shadows. In rooms lighted by side windows, the value of such diffusion, in distributing the illumination and increasing the light on desks most remote from the window, is particularly evident.

The Code refers to the tendency during recent years to make frequent use of the system of general "overhead" lighting, so as to leave the room clear and avoid as far as possible low-hanging fixtures. Now that more efficient and compact powerful illuminants are available it is practicable to produce a very strong and even illumination by this means, and general illumination is thus being applied in many cases where it would not formerly have been used. In rooms with low ceilings the advantage of being able to use lamps of high candlepower but small overall length is considerable.

Following the general remarks on factory lighting there are a number of illustrations of typical factories lighted by general, local and localised general illumination, and some examples of good and bad lighting. Finally, there is an account of methods of cleaning and maintaining lighting appliances, with a view to keeping an installation in good condition.

From this brief survey it will be evident that the Code contains a great deal of useful matter, and we commend it to the notice of our readers.

THE NINTH ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY IN THE UNITED STATES.

In reading the account of the Ninth Annual Convention of the American Illuminating Engineering Society, which took place in Washington last September, one cannot help contrasting the conditions prevailing in the United States with those in Europe, plunged into the vortex of war. In this country, needless to say, the pursuit of scientific study in fields not directly connected with warfare is attended with considerable difficulties, and is naturally restricted at the present time. Many of those associated with the illuminating engineering movement are at present engaged in other fields of labour, either in the army or as advisors or assistants in Government work. Ordinary vocations must suffer, but it is our bounden duty to "keep alive the flame of scientific research" even in war time, and to maintain the machinery for doing so until happier times enable us once more to go "full steam ahead."

We are now approaching another season of the Illuminating Engineering Society in this country, and we feel sure that its supporters will do all in their power to maintain its record of useful work. Meantime we are glad to see that our friends in the United States are as actively at work as ever.

We hope in our next issue to give a fuller account of the papers read at the Convention. On this occasion we can only mention the contents of a few in order to show the wide ground covered in the discussion, and the complete manner in which theoretical investigations and practical experience are becoming linked in illuminating engineering.

It is convenient to deal with the papers in several distinct groups, namely:—(1) those concerned with the eye and visual effects of illumination; (2) those concerned with physical and photometric matters, such as colour, new instruments, and radiation; (3) those dealing with practical applications of illumination and lighting installations; (4) those dealing with miscellaneous problems.

Taking first the papers dealing with eye and visual effects, we note a communication by Cobb, describing some experiments on the effect of vision of the surroundings—a point which was brought strikingly before our notice in the discussion on the lighting of rifle ranges last May.

This matter is also discussed in a paper by Nutting, who makes the statement that in factory lighting a higher order of illumination is invariably required when the contrasts are great. Another interesting point explained by Nutting is the reason why the eye can manage with a far smaller illumination by night than is needful in the daytime. (We have had ample opportunities of testing this point personally during the last few months!) C. E. Ferree and G. Rand contribute a description of experiments on various systems of lighting, in the course of which the effect of contrast is again studied. Special interest attaches to the method of testing eye-fatigue by selecting a certain interval of time and noting the proportion of the interval during which the observer's vision of printed type is respectively "clear" and "blurred." The method is a novel one and will be studied with interest, as there seems to be a need for some convenient standard device for testing eye-fatigue.

In the second group of papers we have a contribution by W. E. Burge, who shows that the physical condition of the eye, as well as the radiation imposed on it, have a great influence on the production of cataract; these

experiments may help to explain many discrepancies that have previously been recorded by workers in this field.

Turning again to visible light, we may note Mr. Luckiesh's contribution on "yellow light." It is evident that, here again, there are many points that have not yet been experimentally settled. At present it cannot be said with certainty that yellow light is specially "easy on the eyes" or the reverse, although there is ground for thinking that the acuteness of vision by monochromatic light is greater than with a continuous spectrum. The author, for instance, approves the use of yellow-green light for targets used in rifle ranges. The greater penetrating power of the yellow and red rays seems to be well established, and Mr. Luckiesh has demonstrated their value for automobile headlights in a mist or fog.

All the above papers deal with interesting physiological points. In the photometric section we have an analysis of the requirements of illumination photometers by T. J. Litle, who raises the oft-debated question as to whether an instrument should be used to measure the current supplied to the small glow lamp; certainly such an instrument must be an exceptionally trustworthy and accurate one to be of value. Litle also discusses the test-plate, and in conjunction with C. H. Sharp describes a highly ingenious type of plate compensated to obey the cosine law strictly; the only drawback is that the plate must be observed vertically. Other contributions deal with the accuracy of standard lamps and the influence of atmospheric conditions upon their candle-power.

Among the third group of papers, which deal with practical lighting problems, there are two dealing with ship-lighting, a subject which we have always believed to offer great scope for investigation. The lighting of ships during construction is a particularly interesting point, as it is well known that accidents are apt to occur when such work is carried by night. It is interesting to note that in a busy shipyard as many as 100,000 candles are often used during the year for this purpose, but temporary electric lighting is now largely employed.

Several papers also deal with street and interior lighting. It is evident that specialists in this field are gradually feeling their way towards more scientific methods, and it will be interesting to notice what steps are taken in the United States in the near future. In this country the normal development of street illumination is naturally in abeyance owing to the restrictions imposed by the war, but it is probable that our present experiences will suggest considerable changes when progress is resumed. Of special interest at the present moment is the account of the illumination of the State, War, and Navy Department Building at Washington.

In view of the recent publication of the First Report of the Departmental Committee on the lighting of factories and workshops, R. E. Simpson's contribution on "Illumination and one year's accidents" is very timely. The author mentions a number of instances of mishaps traceable to defective lighting, and concludes by a series of diagrams showing the seasonal distribution of accidents of this type.

Finally, we may note a series of papers on miscellaneous subjects, including the applications of various illuminants to photography, the industrial uses of gas at the Panama-Pacific Exposition, and the parabolic mirror. It only remains to be said that the Convention appears to have been as successful as usual, and has again served to establish the importance of the field of work covered by the illuminating engineering movement.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

A Report presented by the Committee on Progress (Mr. F. E. Cady, *Chairman*, Mr. T. J. Little, Mr. L. B. Marks, Mr. T. W. Rolph), at the Ninth Annual Convention of the Illuminating Engineering Society, held in Washington, September 20th to 23rd, 1915; slightly abbreviated.)

(Continued from page 414.)

Arc Lamps.

A flaming arc lamp has been developed³⁵ in which the positive electrode is covered by an outside cylindrical layer of illuminating salts, which protect the inner electrode core against the oxygen of the air so that consumption is reduced. The electrode is of homogeneous carbon and the layer used is a mixture of calcium fluoride, sodium tungstate and potassium chromate. The negative electrode is an ordinary homogeneous carbon with a central core. The electrodes must be used vertically and are said to have a life of from 40 to 50 hours. The specific consumption including the series resistance for direct current is given as 0.14 watt per candle.

In the report of the Committee on Progress for 1913, reference was made³⁶ to some work on the relation of pressure and temperature in arc lamps. This work has been continued³⁷ and some

striking results have been obtained. From these results the true temperature of the evaporating solid crater of the positive carbon at atmospheric pressure was deduced as 4,200° centigrade absolute, a value higher by 200° or 300° than that generally accepted heretofore. The temperature of the negative crater was found to be lower by several hundred degrees. If the pressure is decreased below one atmosphere the temperature of the positive crater decreases. When the atmospheric pressure is increased the temperature of the positive crater increases with a corresponding greatly increased efficiency. At a pressure of 22 atmospheres the surface brilliancy had increased to 18 times the value at one atmosphere pressure. These results were obtained with impregnated carbons, it having been found impossible to maintain a "true arc" with pure carbons at pressures greater than one atmosphere. Further experiments are to be made in

³⁵ *Elek. Zeit.*, Nov. 26, 1914, p. 1079.

³⁶ *TRANS. I. E. S.*, Oct., 1913, p. 328.

³⁷ *Zeit. f. Beleu.*, Jan., 1915.

connection with the action of the impregnating salts, the dimensions of the carbons, &c.

In a study³⁸ of metallic arc lamps comparative tests made on ferro-ilmenite and magnetite cathodes using solid copper anodes indicate the superiority of the former. A definite dependence was found between the temperature of the arc and its most efficient length, shorter arcs being more economical at low amperages and *vice versa*. Chromium compounds exercise a cooling effect similar to that of an excessively long arc. The efficiency of the arc was increased by amounts varying from 190 to 133 per cent. by the use of a ferro-ilmenite anode. Indications were that this was due to the heat resistivity of the material, other anodes of materials with approximately the same heat resistivity such as cold rolled steel, vanadium steel and graphite giving similar favourable results.

On alternating current circuits, arcs between carbon electrodes and those between metal electrodes act quite differently owing to the low heat conductivity of carbon. The relighting potential of carbon electrodes on an alternating current circuit of 50 cycles and 3 amperes does not exceed 100 volts, but the relighting potential of metal electrodes under identical conditions is almost equal to a static discharge potential. Experiments have been made³⁹ using an auxiliary arc to counteract the tendency of the metal arc to cool down. Combinations were tried of carbon and ferro-ilmenite electrodes. The results indicated the possibility of using a modification of Duddell's musical-arc circuit for the purpose of sustaining the alternating ferro-ilmenite arc during the zero point in the current curve by supplying the necessary relighting potentials from the circuit itself. It is hoped a commercial alternating current metal arc may be thus developed.

An arc⁴⁰ lamp of an entirely new type is foreshadowed in a patent issued in England for an arc between tungsten or similar electrodes enclosed in a bulb containing nitrogen or other inert gas. The

electrodes are horizontal and of small diameter, and the arc is struck by a simple thermo-mechanical device.

Some recent experiments on the temperature of the mercury arc as used in work on fluorescence have given results indicating values as high as 1,400° centigrade. Measurements were made on the discharge in a tube that had a platinum-iridium thermo-couple sealed into it with one junction situated at the axis of the tube. The temperature of 1,400° C. was deduced by extrapolating about 200° beyond the calibration curve of the thermo-couple. The investigation suggested that in all probability the temperatures indicated by a thermo-couple when exposed directly to the discharge are still very much below that corresponding to the mean molecular kinetic energy of the luminous vapour.

Lamps for Projection Purposes.

Searchlights.—Recently the⁴¹ United States Navy has secured a searchlight of novel form, which has already found application in Europe. This instrument is 44 inches in diameter and has instead of the usual silver mirror, a gold mirror which can be controlled automatically from a distant station. It is claimed that the use of gold gives a beam of light which is more effective in showing detail and has greater penetrating power in case of fog than that coming from a silvered mirror.

In the Swedish army an oxy-acetylene searchlight is being adopted.⁴² This apparatus employs a pellet of ceria on which the oxy-acetylene flame is concentrated. The consumption is stated to be about 40 litres of acetylene and 40 litres of oxygen per hour and enough of both is carried with the instrument to provide for 20 hours burning.

A portable searchlight⁴³ has been developed in this country in which a 20 in. waterproof projector is used with a 750 watt focusing type non-vacuum tungsten lamp. The projector and battery weigh 600 pounds and are mounted on a two-wheeled carriage. One charge of the

³⁸ *Elec. Rev. and W. E.*, Apr. 10, 1915, p. 691.

³⁹ *Elec. Rev. and W. E.*, May 8, 1915, p. 871.

⁴⁰ *Elec. Eng. (Lond.)*, May 27, 1915, p. 229.

⁴¹ *Sci. Amer.*, Apr. 24, 1915, p. 382.

⁴² *Ill. Eng. (Lond.)*, Feb., 1915, p. 84.

⁴³ *Elec. Rlwy. Jour.*, Mar. 27, 1915, p. 639.

battery is designed to give 7 hours continuous service.

Miner's Lamps.—As a result of the stringent rules of the British Home Office there has been a steady development in lamps for use by miners. Six new types have been approved.⁴⁴

The Bureau of Mines has recently revised its specifications for miner's lamps under the caption "Schedule 6-A." The principal changes are in the candlepower rating and in the uniformity test.

Headlights.—A big reduction in power consumption without reduction in illuminating effect⁴⁵ in street and suburban railway headlights has been made possible by the new concentrated filament tungsten lamps which are replacing arc lamps for this work.

The importance of the problem of the glaring auto-headlights which has caused so much adverse legislation and ill-feeling has been recognised⁴⁶ by the Society of Automobile Engineers as demanding immediate attention. A series of tests have been worked out which may be used as a standard definition of what constitutes a dangerous "glare" and the results of such tests will be submitted to manufacturers of headlights with a view to eliminating the trouble at the source. Future headlights are to be constructed according to scientific formulæ removing the glare but thoroughly retaining the far-reaching effect of a searchlight upon the road itself.

A new method⁴⁷ of reducing the glare from auto-headlights consists in the use of small curtains mounted on shade rollers contained in cylinders which may be attached above the lamps. The shades are raised or lowered by means of cords connected to a device operated from the driver's seat. When down they still transmit sufficient light for city driving. Another arrangement⁴⁸ consists in the mounting of two filaments in one bulb, one of 4 candlepower for city use, and one of 20 candlepower for country use. Fittings are now made⁴⁹ which enable a

light to be mounted almost anywhere on an automobile, even on the wind-shield or fenders.

Signal Lights.—Fulfilling the forecast made in last year's report⁵⁰ semaphores are eliminated in a block signal system now being installed on one of the large railroad systems.⁵¹ White electric lights are arranged on a black background so that the three positions of a semaphore can be imitated. Two boards corresponding to two semaphore arms are used for each track, the upper corresponding to the stop signal, the lower to the cautionary signal. These signals are used both by day and night.

The familiar oil lantern carried by train men is being displaced by an electric lantern⁵² built along exactly the same lines, a dry battery being carried in the space formerly occupied by the oil, and a miniature tungsten lamp furnishing the light. Another portable lantern for railroad men consists of a nickel-plated casing,⁵³ the top of which carries the battery, the bottom being flared so as to act as a projector and containing an incandescent lamp. The lamp is turned on or off by the bail which is made to snap into the vertical position when being used.

Owing to reckless automobile driving the old "Stop, look and listen" signs at grade crossings are no longer as efficient as formerly in preventing accidents. In consequence one railroad has inaugurated the use⁵⁴ of large illuminated billboards to educate the public in "Safety First" and warn automobilists and others to use care in crossing tracks. A new type⁵⁵ of railroad track warning signal consists of a blackened tube containing a condensing lens behind which is a strong incandescent lamp backed up by a reflector. The tube is mounted so as to point in the direction from which the motorist will approach and the placing of the light well back in the tube makes it almost as effective by day as by night.

Street traffic controlled by means of

⁴⁴ *Elec. Eng.* (Lond.), May 6, 1915, p. 197.

⁴⁵ *Elec. Rlwy. Jour.*, Mar. 27, 1915, p. 639.

⁴⁶ *Sci. Amer.*, July 17, 1915, p. 59.

⁴⁷ *Pop. Mech.*, Mar., 1915 p. 397.

⁴⁸ *Elec. Rec.*, Apr., 1915, p. 38.

⁴⁹ *Elec. Rec.*, Feb. 5, 1915, p. 26.

⁵⁰ *TRANS. I. E. S.*, IX, No. 6, 1914, p. 530.

⁵¹ *Pop. Mech.*, July, 1915, p. 103.

⁵² *Elec. Rec.*, May, 1915, p. 18.

⁵³ *Pop. Mech.*, June, 1915, p. 893.

⁵⁴ *Elec. World*, July 17, 1915, p. 146.

⁵⁵ *Tech. World*, Apr., 1915, p. 226.

signal lights described in last year's report is being tried out⁵⁶ in Pittsburgh.

There is evidence of the increased use of light as a danger signal. A power station has installed⁵⁷ a system of red lamps on the switchboard gallery which indicate when and where an individual is entering the compartments containing the dangerous high tension apparatus. Another central station uses red lights to indicate that the trolley rail of the ash conveyor is energised and therefore dangerous.

A novelty⁵⁸ in the way of a signal and projection light is a small lamp with a reflector, to be attached to an electric iron. The lamp is connected to the wiring inside the iron. It not only illuminates the cloth in front of the iron, but acts as a tell-tale in case the current is left on when the iron is not being used. Work is also being done on the development of small⁵⁹ pilot lamps for use at the needles of industrial sewing machines.

Fla hlights.—Lately there has been an unusual development in the line of flashlights. One has been brought out exactly⁶⁰ like a fountain pen in appearance and size. It is provided with a pocket slip, is $5\frac{3}{4}$ in. (14.60 cm.) long and $\frac{3}{4}$ in. in diameter, and weighs only $1\frac{1}{2}$ ounces (42.47 gr.). A modification of this idea⁶¹ includes a pencil holder and the lamp can be operated with or without the pencil by means of a thumb slide in the pencil barrel. Still another type⁶² similar to these employs the clip as a switch and is provided with a tongue depressor for use by physicians. A flashlight has also been developed which may⁶³ quickly and easily be attached to an ordinary dry cell.

War.

The great war furnishes an opportunity for the study and an incentive for the development of certain classes of illu-

minants. In its activity may be seen the application of the latest ideas regarding such factors as glare and the power of light of certain colours to penetrate fog. Active fighting is no more confined to daylight than business, and the old type of romantic sorties under cover of darkness are made almost impossible owing to the frequent and brilliant flashes of illumination.

A recently designed signal device consists of a pair of binoculars over which is mounted a small parallel beam flashlight. The "battery for lighting the lamp is carried in the belt of the user. The average range of the instrument is about 3 miles (4.82 km.). An electric flashlight apparatus used by the British is similar in size and appearance to an ordinary camera. A large lens is provided at the front of the box and flashes are made by means of a telegraph key, which closes the lamp circuit.

Searchlights.—Travelling searchlights have been developed by the various nations at war.⁶⁵ Automobile trucks form the carriers and supply the power. The lights may be operated either on the truck or at a distance from it. The French have brought out a device for distance control employing the response of a tuning fork at the searchlight to a vibrating current sent from a contact breaker tuned in unison with the tuning fork. Gilded mirrors are being used instead of glass. Searchlights are used not only to detect the movement of the enemy,⁶⁶ but to blind troops when they are charging across the zone of fire and to discomfort the pilots of aeroplanes. Some of those used will throw an intense light for miles. Owing to the blinding and confusing effect, it has been found to be impossible to advance a body of troops in the face of strong searchlights, a practical illustration of the use and effect of glare.

Illuminants.—Besides searchlights a number of other types of illuminants are being used.⁶⁷ Among these may be mentioned the luminous cartridge which serves for the illumination of nearby

⁵⁶ *Municipal Jour.*, Jan. 7, 1915, p. 12.

⁵⁷ *Elec. World*, June 12, 1915, p. 1556.

⁵⁸ *Elec. Mds.*, June, 1915, p. 165.

⁵⁹ *Elec. World*, June 12, 1915, p. 1557.

⁶⁰ *Elec. News* (Can.), Mar. 15, 1915, p. 37.

⁶¹ *Elec. Rec.*, May, 1915, p. 18.

⁶² *Elec. World*, May 15, 1915, p. 1258.

⁶³ *Elec. Rec.*, June, 1915, p. 21.

⁶⁴ *Sci. Amer.*, Oct. 24, 1914, p. 334.

⁶⁵ *Elec. World*, May 15, 1915, p. 1262.

Sci. Amer. Sup., Oct. 3, 1914, p. 209.

⁶⁶ *Sci. Amer. Sup.*, July 10, 1915, p. 23.

⁶⁷ *Jour. f. Gas.*, May 1, 1915, p. 238.

fields and especially for investigating and exploring purposes. It is fired from its own pistol and has a range of action of about 200 metres and a luminous area of about 100 metres. It burns from 8 to 10 seconds. Similar to it, but with much larger luminous activity is the light-rocket which is discharged from a musket. It is fired distances from 45 to 900 metres and its intensity is so great that it lights up an area from 500 to 600 metres in diameter with an illumination almost as great as daylight and lasting from 30 to 40 seconds. Flares have been developed from fireworks and are similar to what are known as red, white, and blue fires used in Fourth of July celebrations. These are set out by sappers a distance in front of the battle line and are controlled from the headquarters of the officers. Ignited at intervals they keep the battle front illuminated throughout the night. Star bombs shot from mortars maintain an intense illumination for intervals as long as 20 minutes. For distance lighting a projectile similar to shrapnel is used, so constructed that it furnishes light after a definite time and at a predetermined height. Air bombs are constructed for use by aeroplanes. Torches have been developed which burn from 2 to 3 hours.

Profiting by conditions in the European war, the Secretary of War has directed the Engineering Corps to make an exhaustive study of and experiments with the use of searchlights, flares, star bombs, and other lights by troops in the field.

Portable Lamps.—The war has caused a considerable development in the way of pocket lamps in Germany.⁶⁸ In one type of hand lamp an ingenious mounting of the lamp in conjunction with a movable screen enables the light to be directed at various angles with the vertical and still be properly screened from observation. Another type⁶⁹ has an arrangement holding a pad and pencil with the light so concealed that only the pad is illuminated. Still another type⁷⁰ is in the form

of a hemisphere, the inner surface of which is polished, and with the lamp may be used as a small searchlight.

Use is being made of acetylene for the illumination of portable hospitals.⁷¹ Limitations in the supply of oil⁷² have led in Germany to an effort to use coal gas in the lighting of trains in place of oil gas previously used. Among the other sources of light for ordinary purposes used in the war zones should be mentioned kerosene or paraffin oil lamps with incandescent mantles.⁷³

Safety Lighting.—The danger from night raids by Zeppelins or other air craft has made it advisable to reduce the lighting in cities and towns in England and France. In Paris⁷⁴ in the neighbourhood of the Eiffel tower, lighting has been cut out almost entirely. As a sample of the orders for reduced lighting used in London may⁷⁵ be mentioned the following: In all brightly lighted streets, squares, and bridges a portion of the lights must be extinguished so as to break up all conspicuous groups or rows of lights and the lights not extinguished must be lowered in intensity, or made invisible from above by shading them or painting over the tops of the globes, providing that while thick fog prevails normal lighting may be resumed. Sky signs, illumined facias, illuminated lettering and powerful lights of all description used for outside advertising or for the illumination of shop fronts must be extinguished. Subsequently the above orders⁷⁶ were made more inclusive by prohibiting all lights outside of shops. This same order called for rear lights on vehicles. It is interesting to note that while we have had rear light ordinances for years it has taken war conditions to make the desirability of such lights apparent in London. As a result of the above requirements special reflectors have been developed.⁷⁷ In consequence of the lighting conditions it is claimed that there has been a large increase in fatalities

⁷¹ *Pop. Mech.*, June, 1915, p. 829.

⁷² *Acet. Jour.*, April, 1915, p. 387.

⁷³ *Jour. of Gas Light.*, June 15, 1915, p. 659.

⁷⁴ *Ill. Eng. (Lond.)*, June, 1915, p. 289.

⁷⁵ *Jour. of Gas Light.*, Dec. 22, 1914, p. 652.

⁷⁶ *Jour. of Gas Light.*, Dec. 17, 1914, p. 637.

⁷⁷ *Elec. Times*, Dec. 31, 1914, p. 609.

⁶⁸ *Elek. Zeit.*, Oct. 22, 1914, p. 1030.

Elek. Anz., Mar. 28, 1915, p. 163.

Elek. Anz., May 9, 1915, p. 240.

⁶⁹ *Elek. Anz.*, May 16, 1915, p. 254.

⁷⁰ *Elek. Anz.*, May 23, 1915, p. 269.

caused by accidents.⁷⁸ Curious complications have arisen over the question of payment on the part of shopkeepers for exterior illumination which they are not receiving.⁷⁹

Experiments have been made by one of the street car companies of London⁸⁰ to meet the requirements of reduced lighting and still furnish light enough to allow the passengers to read and conductors to cancel tickets. As a result of these experiments lamp shades used in the lower part of the car are dipped in a violet lacquer, thereby reducing the illumination by 50 per cent. In the upper part of the car a similar treatment is given and the shades arranged so as to throw the light across the car. The dash lights are covered over with yellow paper. Experiments on dipping the lamps themselves were found to give unsatisfactory results.

The restrictive lighting regulations have emphasised the waste occurring in many show windows⁸¹ and the desirability of considering the principles of illuminating

engineering, in order to get good results. Interesting experiments⁸² are to be carried out in London to diminish the inconvenience to the public due to the low public lighting. Street curb stones are to be painted white and householders are requested to paint similarly all door steps leading from sidewalks. Not only in the field of active operations but also at home⁸³ the question of illumination has been a matter of vital importance in the various camps formed to take care of troops newly recruited, or en route from various parts of the country. Such camps cover an area of about 250 by 500 yards (228.6 by 457.2 m.) and contain 80 ordinary huts, 27 officers' huts, dining rooms, guard rooms, etc. About 1,200 lamps are employed.

The restrictions of lighting in so many towns in England has retarded the extensive use of the new types of high candlepower, high efficiency lamps. One of the effects of the war has been the recognition in Russia of the need of manufacturing her own incandescent lamps.⁸⁴

⁷⁸ *Elec. Times*, May 6, 1915, p. 399.

Ill. Eng. (Lond.), July 1915, p. 300.

⁷⁹ *Jour. of Gas Light.*, Jan. 26, 1915, p. 182.

⁸⁰ *Elec. Ry. Jour.*, Dec. 26, 1914, p. 1398.

⁸¹ *Elec.*, Dec. 11, 1915, p. 331.

⁸² *Elec. World*, July 17, 1915, p. 158.

⁸³ *Elec. Eng.* (Lond.), Dec. 24, 1914, p. 649.

⁸⁴ *Elec. Rev.* (Lond.), Mar. 12, 1915, p. 634.

(To be continued.)

NATIONAL ILLUMINATION COMMITTEE OF GREAT BRITAIN.

(Affiliated to the International Commission on Illumination.)

Constituted by Co-operation of:—

The Illuminating Engineering Society.
The Institution of Electrical Engineers.
The Institution of Gas Engineers.
The National Physical Laboratory.

A MEETING of the National Illumination Committee of Great Britain was held at the Institution of Electrical Engineers on 20th October, 1915, when it was reported that Mr. Jacques Abady, of London, has been nominated by the Institution of Gas Engineers as a member of the Committee to fill the vacancy caused by the death of Mr. Edward Allen, of Liverpool. The Committee elected Mr. W. Duddell, of London, to be its Chairman in succession to the late Mr. Edward Allen, and Mr. John Bond, of Southport,

to succeed Mr. Duddell as one of the Vice-Chairmen.

Reports on observations, carried out at the instance of the Committee at a number of technical laboratories, on the height to which the flame of the Hefner amyl acetate lamp should be raised to afford a light of one International or English standard candle, were discussed, and their further consideration was postponed until fuller details of some of the observations and other reports which had been promised had been obtained.

A report prepared and sent by Dr. E. Ott, of Zürich, on researches which had been carried out in Switzerland on the Effect of Atmospheric Pressure, Humidity and Vitiation on the Light afforded by the Hefner Standard Lamp was considered, and it was decided, subject to Dr. Ott's consent being obtained, to prepare a translation of the report for communication to the English technical Press.

A SUGGESTED CODE OF LIGHTING FOR FACTORIES, MILLS AND OTHER WORK PLACES IN THE UNITED STATES.

(Presented at the Ninth Annual Convention of the Illuminating Engineering Society, U.S.A., held in Washington, September 20th to 24th, 1915 ; abbreviated.)

(Continued from page 419.)

Section II. Value of Adequate Illumination.—Factory and mill owners are concerned in the matter of securing the largest output for a given manufacturing expense. An improved machine tool capable of increasing the product for given labour costs is most attractive, provided its first cost is within returnable limits out of the larger profits. Improved small tools, better methods of handling material, adequate crane service, fire protection, good shop floors, accurate and efficient time-keeping methods, and similar items, vitally concern the shop manager ; money is expended to realise excellence in these features because they afford increased economies and protection, thus resulting in a higher efficiency of the plant.

Energy Consumption a Minor Item.—Many arguments leading to the sale of gas and electric lamps for use in factory and mill buildings are based on reducing the lamp operation cost by substituting a new for an older system. Arguments of this kind are of value, however, only when such a reduction in operation cost can be effected without sacrifice in the adequacy of the illumination. It would be a poor policy, in the extreme, to argue a saving in energy consumption by the substitution of one type of lamp for another on a basis of equal candlepower in both old and new systems.

Effect of Good Light on Production.—Arguments of a convincing nature, which insure to the factory or mill manager an increased output through improved illumination service, are of importance and even greater at times than reductions in the cost of illumination for the same quantities of light. In view of the fact that resulting

advantages of superior illumination on increased output are apt greatly to exceed economies in operation cost as regards the lighting system, it is a distinct advantage to direct and hold the attention on the former rather than on the latter. This statement will be more apparent when interpreted into definite items as follows :

Advantages of Good Light.—While the necessity of good natural and artificial light is so evident that a list of its effects may seem commonplace, these same effects are of such great importance in their relation to factory and mill management, that they are well worth careful attention. The effects of good light, both natural and artificial, and of bright and cheerful interior surroundings, include the following items :

1. Reduction of accidents.
 2. Greater accuracy in workmanship.
 3. Increased production for the same labour cost.
 4. Less eye strain.
 5. Promote better working and living conditions.
 6. Greater contentment of the workmen.
 7. More order and neatness in the plant.
 8. Supervision of the men made easier.
- In this list it will be noted that items 4, 5, 6, 7 and 8 all have a bearing on accident prevention.

Interpreting the Advantages of Good Light.—While the major consideration in the eyes of the factory or mill owner is undoubtedly and quite naturally the money value of good light in the larger return of both quantity and quality of work which may result from the installation of a superior as compared with an inferior lighting system, it should be noted

that it is very difficult to interpret into dollars and cents the value of good light made possible by such returns. This difficulty is due to the necessity of keeping all conditions in a factory or mill section absolutely constant while varying the amount of illumination from poor to good conditions, in an effort to determine the output and its dependency on the lighting facilities. *As accurate data becomes available*, giving the increases in production for certain specific improvements in artificial lighting, it will doubtless prove helpful to a proper interpretation of adequate light and its worth to any plant.

The eight foregoing points are emphasised as forming the most important features in the problem of good lighting. Although difficult to interpret into money values, and somewhat intangible, they are indisputable arguments in favour of the best available illumination from the standpoint of the factory or mill owner.

Practical Example.—Continuing from the manufacturer's point of view, it may be said that certain assumptions as to energy cost, cleaning, interest and depreciation, show that the annual operation and maintenance cost for the illumination of a typical shop bay of 640 sq. ft. area, may be taken at \$50.00. If five workmen are employed in such a bay at an average wage of say 25 cents per hour, the gross wages of the men in such a bay, plus the cost of superintendence and indirect shop expense, may equal from \$5,000 to \$7,000 per annum. In a case of this kind, therefore, the lighting will cost from 7/10 to 1 per cent. of the wages, or the equivalent of less than 4 to 6 minutes per day. We may roughly say that a poor lighting system will cost at least one half this amount (sometimes even more through the use of inefficient lamps and a poor arrangement of lamps), or the equivalent of say 2 to 3 minutes per day. Nearly all factories and mills have at least some artificial light, hence, in general, if good light enables a man to do better or more work to the extent of from 2 to 3 minutes per day, the installation of good lighting will easily pay for the difference between good and bad light, through the time saved for the workmen.

Actual Losses.—Superintendents have stated in actual instances, that due to poor

light their workmen have lost much time, sometimes as much as from one to two hours per day or certain days. If good light will add an average of say one-half an hour per day to the output, these 30 additional effective minutes represent an increase in output of 5 per cent., brought about through an expenditure equal to $\frac{1}{2}$ of 1 per cent. of the wages for improved lighting, or a saving equal to ten times the expense.

Safety.—While these features are of special interest in the eyes of the manufacturer, the principal item to consider, perhaps, from the legislative side of the question, is the necessity of an act or acts to provide employees of workshops with proper and sufficient illumination from the standpoint of safety. The legal aspect of the safety question in its relation to illumination in factory and mill buildings, is a topic of unusual importance.

Section III. Old and New Lamps.—

The inadequate means available for illumination by artificial methods in the past have contributed to the slowness of an appreciation of the features of artificial light which influence the working efficiency of the eye. Open flame gas burners, carbon incandescent and arc lamps, practically the only illuminants available ten years or so ago, play but a small part in the present approved methods of factory and mill lighting.

New Lamps.—The large variety of comparatively new lamps available for factory and mill lighting includes the mercury vapour, metallised filament, tungsten, gas filled tungsten, metallic flame or magnetic arc, the flame carbon arc, the quartz mercury vapour, and various types of gas arc lamps. Remarkable improvements have thus been made in both the electric and gas lighting fields, the same general rules of applying the lamps covering both of these fields. Possibilities in factory and mill lighting are now attainable which, before the introduction of these new lamps, were either unthought of or impossible. Consideration of the eye as a delicate organ, together with the new ideas of the items which affect its comfort and efficiency, have resulted in establishing certain principles in illumination work, and have directed attention naturally and

in a growing manner to the proper use and application of these new lamps.

Section IV. Effects on Factory and Mill Lighting Produced by Modern Lamps.

—With the introduction of these new gas and electric lamps, broader possibilities have been presented in factory and mill lighting. The use of units of sizes adapted to the purposes, allows results which it has been hitherto impossible to obtain satisfactorily, either by the arc lamp, carbon filament or open flame gas burner, formerly available.

New Possibilities.—It is evident that the introduction of the many new lamps has made possible what may be termed a new era in industrial illumination, a distinctive feature of which is the scientific installation of the lighting units, suiting each to the location and class of work for which it is best adapted. Before the availability in recent years of medium sized gas and electric units the choice of the size of unit for a given location was often no choice at all. In many cases, due to small clearance between cranes and ceilings, or other conditions making it necessary to mount the lamps very high above the floor, but one size or type of unit was available, the carbon filament or open flame gas burner in the former, and the arc lamp in the latter case.

Low Ceilings.—For low ceilings, up to 18 ft., the use either of carbon filament, open flame gas burner, or arc lamps resulted usually in anything but uniform light over the working plane, and often produced merely a low general light which was practically useless for the individual machine. In such instances, individual lamps had to be placed over and close to the machines. With this arrangement, relatively small areas are lighted by each lamp, and the metal shades usually employed, serve only to accentuate the "spot lighting" effect. Such a form of illumination for factory and mill work is unsatisfactory and inefficient, but as stated, was in the past, in many cases, the only available scheme. *The absence of lamps of the proper size is no longer an excuse for the existence of such conditions in industrial plants.*

Section V. General Requirements of Artificial Lighting.

—The following re-

quirements for factory and mill lighting are made all the more important by the peculiar limitations and the wide variety of conditions to be found in factory and mill buildings and in factory and mill work :

1. Sufficient illumination should usually be provided for each workman irrespective of his position on the floor space.

2. The lamps should be installed and selected so as to avoid eye strain to the workmen.

3. The lamps should be operated from sources of supply which will insure reliable illumination results, particularly on account of the demoralising effect produced by intermittent service, just when the light may be most needed.

4. Adequate illumination should be provided from overhead lamps so that sharp shadows may be prevented as much as possible, and in such measure that individual lamps close to the work may be unnecessary except in special cases.

5. The type and size of lamp should be adapted to the particular ceiling height and class of work in question.

6. In addition to the illumination provided by overhead lamps, individual lamps should be placed close to the work if they are absolutely necessary in the eyes of a lighting expert, and in such cases the lamps should be provided with suitable opaque reflectors.

These requirements may now be met by means of the new types of gas and electric lamps, one type of which can usually be found for practically each factory and mill location, specially adapted to the general physical conditions of the location as typified by the clearance between cranes and ceiling and other similar items.

Section VI. Overhead and Specific Methods of Artificial Lighting.

—Factory and mill lighting may be classified under two general divisions: first, distributed illumination furnished from lamps mounted overhead; and second, specific illumination furnished by individual lamps located close to the work. For practical purposes this classification is sufficient. In numerous cases a combination of these two methods becomes necessary.

Mounting the Lamps High.—Where the lamps are high enough to be out of the

line of ordinary vision, and are of a size and so spaced as to furnish illumination at any position of the floor where work may be carried on, the system is referred to as the *overhead method* of lighting. This method has many advantages. Its general adoption, which has been somewhat slow, has increased with the appearance of the many new types of lamps and with the growing appreciation of the value of good lighting.

Where a small amount of general or overhead lighting is coupled with specific lighting from individual lamps, a large part of the floor space in many shops is in relative darkness, and much dependence must be placed on the hand lamps close to the work. The small number of overhead lamps generally used in such cases, furnishes merely a small amount of additional illumination over the floor space which is not sufficient to be of much value. However, where sufficient intensity is provided by general illumination, this is often a very effective means of lighting a large work-room.

Low Ceilings.—Locations with low ceilings, until recently, have been lighted by the individual hand lamp method, because the old carbon filament lamps, being of low candlepower, could not well be used close to the ceiling, while the old type of arc lamp was often impracticable, due to its large physical size, as well as its relatively high candlepower. This statement is subject to some modification, because low candlepower units have sometimes been used in clusters for low ceilings as a compromise between a single small or a single large unit, this scheme being, however, usually insufficient and unsatisfactory in comparison with modern methods of lighting. In a particular manner, therefore, suitable illumination has been difficult with low ceilings.

New types of gas and electric lamps have a range of candlepower from very low to very high values, and the overhead system with the elimination of individual lamps is thus possible, in other words, a size of gas or electric lamp may now be selected from a large available list of sizes for nearly every factory or mill condition.

In Section VII various arrangements of lamps are discussed, and illustrated by diagrams and photographs. It is neces-

sary to consider (1) how high lamps may be mounted; (2) are a large number of light sources needed, or may a few suffice?

With ceilings under 16 ft. high candle-power lamps can hardly be used. With ceilings higher than 25 ft. large candle-power lamps have advantages. In general a large number of small units give more even illumination and obviates inconvenient shadows, but, by careful attention to the correct positions of lamps, it is sometimes possible to reduce their number.

Section VIII. Lighting Circuits for Electric Lamps and Supply Mains for Gas Lamps.—The question of lighting circuits is mentioned here with particular reference to factory and mill conditions, where motor loads are apt to be large in comparison to the energy consumption of electric lamps which are in service. In some cases, the proportion of motor load to lighting load is in the ratio of 10 to 1, in others 7 to 1, and so on, and the varying demands on the circuits by motors may greatly affect the lamps. Hence it is important to maintain strictly separate supply circuits for the lamps in order to avoid varying voltage which is apt to result if the motors are connected to the same circuits with the lamps.

Constant Voltage.—In addition to the superior illumination resulting from lamps supplied from constant voltage mains, some types operate with longer life or very much better mechanically when supplied with constant voltage than otherwise. These features will therefore generally more than offset the somewhat greater cost of maintaining separate circuits for each class of service. In like manner and for similar reasons, it is advisable to place gas lamps on supply lines separate from those delivering gas for power purposes.

Section IX. Control of Lamps and Arrangement of Switches.—The control of lamps in factory and mill lighting is important in all cases, but specially so where a large number of lamps is used in preference to a small number for a given floor area. For example, where an overhead system of tungsten lamps of small size is used, a large number will, of course, be necessary for a given floor area, and in

such cases the number of control circuits may at times seem excessive when planned out for sufficient flexibility of operation. Such circuits, however, in rendering the system more flexible, will be more than paid for by the saving in energy and maintenance due to the turning out of lamps not needed in certain sections of the factory or mill, provided the number of hours per day during which the lamps are used on the average is relatively large, and the differences in daylight intensities over the floor area is also relatively large.

Control Parallel to Windows.—The lamps most distant from the windows will usually be required at times when the natural light near the windows is entirely adequate, thus making it an advantage to arrange the groups of lamps in circuits parallel to the windows. The advantage of this method is further apparent when it is considered that if the lamps are controlled in rows perpendicular to the windows, all lamps in a row will necessarily be on at one time, while a portion only may be required.

Practical Case.—The foregoing statement may be developed into a definite proposition. Thus, to install a single switch may involve say \$5.00 as its first cost. If ten lamps are to be controlled from a single switch, these ten lamps must obviously either all be turned off at a time or all turned on at a time. An additional switch at a cost of \$5.00 will permit either half of these ten lamps being turned off, if not required at certain times when the remaining five are needed. This extra switch may or may not be an economy. Consider, for example, the case where these five lamps are of the 60-watt tungsten type, and that they are turned off by the extra switch on an average of one-half an hour per day while the others are needed, or *vice versa*. In a year's time, the energy saved at 1 cent per kilowatt-hour, will amount to perhaps 50 cents. At this rate it will require ten

years for the energy saved to pay for the first cost of the extra switch. This would not be considered a distinct economy. If, however, the energy cost be greater, and more nearly the average under actual conditions, or if the number of hours per day during which a portion only of the lamps will not be used, be greater, then these values will be correspondingly modified.

Locating Switches and Controls.—In locating switches or controls in factory and mill aisles, care should be exercised to arrange them systematically, that is, on columns situated on the same side of the aisle and on the same relative side of each column. This plan materially simplifies the finding of switches or controls, by those responsible for turning on and off the lamps, and is particularly important where a given floor space is illuminated by a large number of small or medium sized lamps distributed uniformly over the ceiling area, a feature which is usually accompanied by the use of a relatively large number of switches or controls.

Section X. Systematic Procedure Should be followed in Changing a Poor Lighting System Over to an Improved Arrangement.—When undertaking the change from an old to a new lighting system, the various forms of illumination which are adapted to factory and mill spaces should be studied, and an investigation made of the various types of gas and electric lamps on the market which are available for the purpose.

Time should be allowed for a study of the given locations to be lighted; for preparing the plans of procedure in the installation of the gas or electric lamps and auxiliaries; and for customary delays in the receipt of the necessary supplies and accessories to the work in hand. Altogether, therefore, work of this kind requires considerable time for its completion.

(To be continued.)

THE DEVELOPMENT OF THE ELECTRIC INCANDESCENT LAMP DURING THIRTY-FIVE YEARS.

AN interesting article in the *Electrical World* for October 16th traces the development of lamp sales in the United States since Edison's discovery. Regular manufacture, it is stated, began at Menlo Park, N.J., in 1880, when 25,000 lamps were made. In the following year the production was increased to 30,000. Thirty years later the output of lamps in the United States had reached the enormous figure of 80,000,000. Progress is

shown graphically in Fig. 1 and Fig. 2, which also indicate the gradual transition from carbon to metal filaments from 1907 at the present day. Equally striking are the diminution in the price of lamps and the steady gain in efficiency.

The following figures are interesting as showing the percentage of total sales of the chief standard sizes of lamps :—

	1913.	1914.
25 watt	29·34	26·78
40 watt	27·11	26·32
60 watt	15·08	16·72
100 watt	5·72	5·80

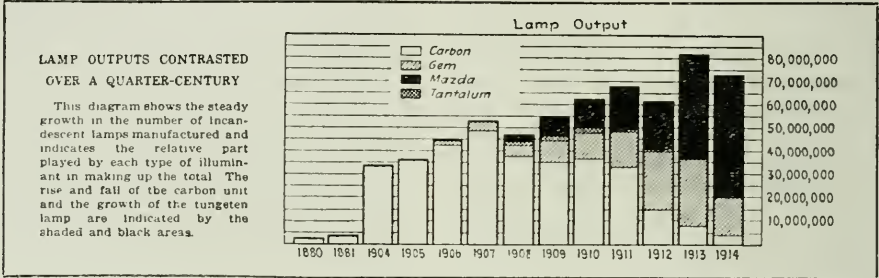


FIG. 1.

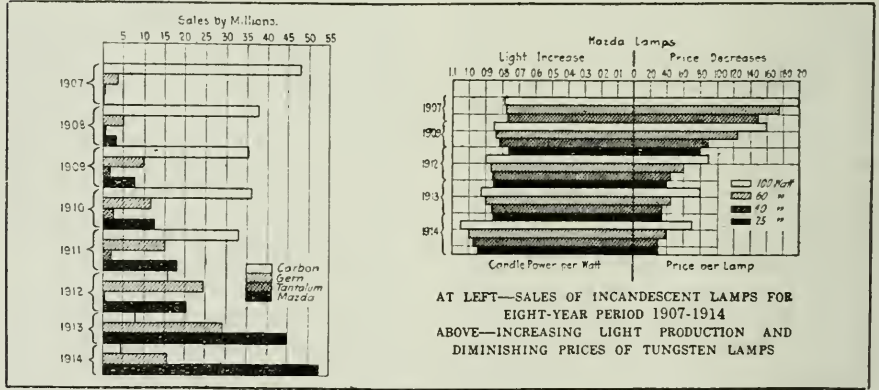


FIG. 2.

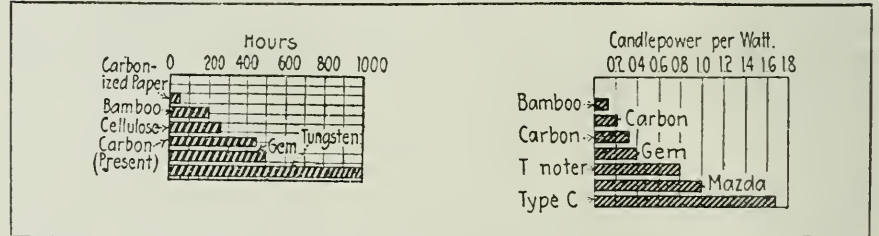


FIG. 3.—Comparisons of burning hours and luminous efficiencies of early carbon and modern incandescent units.

The problem of obtaining a similar record of sales in this country is doubtless more difficult. It would, however, be a useful piece of work of great interest to the lighting industry, and the leading lamp companies might well take the matter in hand.

DAYLIGHT ILLUMINATION IN THE SCHOOLROOM.

THE following paragraph, which is taken from the Report of the Medical Officer of Health (Dr. I. D. Jenkins), Rhondda Education Authority, 1914, illustrates the special difficulties met with in some localities in the natural lighting of schoolrooms. The school is evidently situated in a hilly district, and the windows are overlooked to a considerable extent.

"With a few noticeable exceptions a sufficiency of light is admitted by means of windows into the classrooms of the schools. In many instances, however, the direction from which the light enters in relation to the position of the desks and blackboards is faulty, and apparently incapable of being remedied without material structural alterations. In some of the schools the use of artificial light—usually coal gas, sometimes electric light—is necessary before the dismissal of the children owing to the extent to which the windows are overlooked by erections or adjacent hills. In other instances again the appropriate and full use of the windows is rendered impossible by the extent to which some of the glass, especially in the upper panes, is obscured by dust which has been allowed to accumulate undisturbed for considerable periods owing, usually, to the inability of the female cleaners often employed to reach these positions without undue personal risk."

In view of the importance of the light received from the upper portion of the windows the accumulation of dust on this part of the glass, as mentioned in the Report, is particularly disadvantageous.

School authorities may be recommended to pay special attention to this point.

ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

ANOTHER SERIES OF LECTURES AT THE
JOHNS HOPKINS UNIVERSITY
CONTEMPLATED.

A MEETING of the Council of the Illuminating Engineering Society was held, October 14th, in the general offices of the Society, 29, West 39th Street, New York, N.Y.

After considering the appointments to various committees for the present year, preliminary plans were discussed for the holding of a semi-annual convention in New York next February to mark the tenth anniversary of the organisation of the Society.

It was also planned to arrange for the presentation of a course of lectures on illuminating engineering similar to the course which was given in the autumn of 1910 at the Johns Hopkins University under the auspices of the Society. The programs of papers and meetings for the various sections of the Society were read and discussed briefly by the vice-presidents representing the various sections of the Society. Those present at the meeting were: President Charles P. Steinmetz, H. Calvert, Wm. A. Durgin, Clarence L. Law, M. Luckiesh, A. S. McAllister, L. B. Marks, Treasurer, J. Arnold Norcross, and G. H. Stickney.

PRESENT PRACTICE IN THE SALE OF GAS IN THE UNITED KINGDOM.

By F. W. GOODENOUGH.*

IN this paper Mr. F. W. Goodenough summarised the enterprising steps that have been taken during recent years to develop the gas industry in this country. Particular interest attaches to his account of the methods adopted to secure the goodwill of the consumer and lead him to recognise that the company is aiding him to make the best use of the illuminant—a policy which every up-to-date company should adopt in these days.

Co-operation with the Public.

Effective salesmanship in the gas industry, Mr. Goodenough remarks, involves the recognition of the following facts:—

(1) If you want every consumer to use as much gas as he can consume with profit or advantage to himself you must make it easy for him to get an adequate and constant supply, and to get the most efficient appliances for its use. Then you must see that his appliances are kept constantly in efficient order.

(2) If you don't tell every consumer what you and your commodity are willing and able to do for him he very likely won't know.

(3) If you want to consolidate your business on the surest foundation you must get it fixed in the minds of every one of your employees that the consumers' interests and those of the business are parallel and not opposite; and your whole policy of dealing with the public—whether it be in giving advice, in rendering service, in receiving and dealing with complaints, or in settling disputes—must be based upon a conviction of that truth.

A policy founded upon these facts necessarily implies:—

(a) The laying of adequate mains, the installation of capacious carcass pipes, and the maintenance of a good and steady pressure; the provision of slot meters for the poorer class of consumer; easy terms for the supply and fixing of apparatus; well equipped show-rooms in suitable positions staffed with trained salesmen and women; an efficient fitting staff; an equally efficient maintenance staff; reasonable maintenance terms.

(b) Effective publicity, including local, district and national press advertising; expert canvassing; lectures, both domestic and scientific; good public and store front lighting.

(c) The provision and training of a good commercial and administrative staff imbued

with "the spirit of the house" right down from the chairman of the board to the telephone operator, the office boy and the door-keeper.

Adequate Pressure.

Among other points of importance are the maintenance of a good and steady pressure. Present practice tends towards the use of much higher pressures than were available in the old flat flame days: 30 or 40 tenths is now a common pressure at the meter, and in these circumstances a variation of 3 or 4 tenths is a much less noticeable matter than if the pressure ranged about 15 tenths.

Improved Gas Fittings.

Mr. Goodenough also points out the improvement which is now taking place in the design of fittings:—

Great improvement has taken place in recent years in the design and construction of gas appliances, especially inverted burner lamps for both high and low pressure, gas fires and water heaters. The leading manufacturers are expending considerable sums of money on laboratory research and testing work, and some gas managers stimulate this by themselves applying stringent tests to any lighting or fuel apparatus submitted before accepting it as suitable for sale or hire to the public. The setting-up of a high standard in this way by those gas undertakings which can afford to run laboratories and employ scientific examiners of apparatus benefits the whole industry by raising the quality of all goods produced. Fortunately the gas fittings and apparatus makers of to-day realise more fully than ever the importance of ensuring high efficiency and scientific construction in all appliances for the consumption of gas; and all but the "back number" gas managers realise that the most economical and efficient burner, stove or furnace, and not that which is wasteful of gas, is their best friend in the long run.

The equipment of attractive show-rooms is becoming thoroughly appreciated by British gas enterprises. In this country there is a steady improvement in the showrooms, and demonstrations and lectures form now a common feature. It has also been found that there is an important field for lady advisers, who are naturally able to appreciate many points in connection with the domestic use of gas and to bring these home to consumers.

Maintenance of Gas Appliances.

Many companies have now taken upon themselves the task of supplying, fixing

* Abstract of Paper presented before the International Gas Congress, held in San Francisco, Sept., 1915.

and maintaining all kinds of gas appliances for lighting, heating and cooking, so that the provision of a competent fitters and maintenance staff is quite an important problem. As is well known, a scheme was instituted by Sir Corbet Woodall some years ago for the training of competent fitters and members of the sales department. Under the auspices of the Institution of Gas Engineers annual examinations are now held by the City and Guilds of London Institute, and courses of apprenticeship have been organised for boys taken direct from the London County Council Schools.

The following account of the methods adopted in the maintenance of burners and apparatus will be of interest to many of our readers:—

The need for maintenance to follow upon installations of gas appliances is becoming generally recognised in this country. That recognition has first of all taken the shape of the establishment of arrangements for the periodical cleaning and remantling of consumers' burners and lamps, and such mantle maintenance schemes are pretty general throughout the country.

They are generally worked on one or the other of two plans. Under the first, the consumer contracts to pay a fixed quarterly or annual charge per burner for periodical overhauling and the supply of all materials. This work is generally undertaken at a loss, the charges covering little more than the cost of the materials supplied.

The other plan is for the undertaking to contract to send men periodically to examine and clean the burners, globes, &c., making no charge for the labour but invoicing all materials supplied at something above cost.

The second plan is more favoured by consumers in private houses, where a good many burners are only in very occasional use; but for business premises it has the disadvantage that it leaves the decision as to whether mantles shall or shall not be renewed too much to the consumer who may sacrifice efficiency to economy, with the result that his premises are a bad advertisement for gas lighting; whereas under the first plan the expense of putting on sufficient mantles to keep the lighting in first-rate order falls upon the gas undertaking, whose obvious interest is to see that the consumer gets the very best light for the gas consumed.

The necessity for the maintenance of gas cooking and heating appliances is perhaps not quite so generally recognised as the need for mantle maintenance, though it is really just as important. Every gas cooking and heating stove should be periodically examined and, where necessary, put in working order, as many gas consumers do not recognise when a gas appliance is out of adjustment and put up with unsatisfactory results which create a wrong impression in their minds and in those of others.

It is to be remembered that it is even more important to retain and consolidate old business than to obtain additional business, and that the former makes the latter an easier task.

Some undertakings in this country (and the number is steadily increasing) have fully realised this and have established a system for the periodical inspection and adjustment of all their consumers' gas appliances. Generally no charge is made for this service except so far as the supply of new parts is concerned. In the case of apparatus on hire, the necessary parts for repair are, of course, supplied free of charge.

We have no doubt that this work will bear good fruit in the future and that, as time goes on, the number of men actively interested in the scientific utilisation of gas for illumination will steadily increase.

The concluding portion of Mr. Goodenough's paper contains an account of the well-organised work of the British Commercial Gas Association. Although, needless to say, much of this educational work is familiar to readers of this Journal, it is useful for us in this country to take stock, from time to time, of the steady progress being made in the education of the consumer, and the account given by Mr. Goodenough of this work must have been particularly interesting to gas engineers in the United States.

LIGHTING RESTRICTIONS AND COAL DELIVERIES.

LIGHTING restrictions are having some unlooked-for effects. At a recent conference in Edinburgh between the Corporation and the coal merchants, it was pointed out by the latter that in the absence of any public lights on the dark mornings the delivery of coals was a serious matter, and unless something could be done to help them, deliveries would have to be deferred until daylight. They suggested that the public electric lamps might be put on at 6 a.m. during the dark season. The Electric Lighting Committee have agreed to recommend the Town Council to light the lamps in the main thoroughfares as suggested. Also, the St. Pancras Borough Council suggest that the rate collectors shall not keep their offices open at night, owing to the dangers of the streets and the risk in the transit of money received during the evening.—*The Gas World*, 30th October, 1915.

ILLUMINATING ENGINEERING IN GERMANY.

SINCE the commencement of war readers have doubtless wondered occasionally what is the state of the lighting industry in Germany, and whether the technical and scientific work of the country is being carried on as usual. So far as can be gathered from the technical papers lighting arrangements have not been greatly interfered with, although the depletion of the staffs of electric supply companies has been a difficulty. One would also imagine that the comprehensive arrangements for the commandeering metals and other materials for war purposes must have had a pronounced restrictive effect on trade.

It is stated that the shortage of petroleum in Germany, where oil is very largely used for lighting among the poorer classes, has even had the effect of stimulating electric lighting. The manufacture of electric torches has also increased very rapidly owing to the demands of the German army, and it is inferred from the large number sent to neutral countries that some of them also find their way into the armies of the allies!

We notice that a number of papers of a scientific and technical character have been read before the German Illuminating Engineering Society. The subjects for discussion resembled in the main those in other countries. In our August issue, for example, we noticed a paper by Lux dealing with the photographic action of various artificial illuminants, and there has been some discussion on the use of half-watt lamps for portraiture by artificial light—a subject which has recently been dealt with by the Illuminating Engineering Society in the United States.

Among other papers we notice a contribution by Bloch on the definition of

the colours of surfaces in terms of the primary colours; the reflecting power for red, green, and blue light being suggested as a possible criterion. Herr v. Pirani gives an account of a new method of heterochromatic photometry, which has been noticed elsewhere in this Journal.* Bechstein summarises the results of a series of photometric tests on the agreement of various observers when comparing white and heterochromatic lights. These observers were novices in photometry, but even so the variations seem considerable.

Perhaps the most interesting item, however, is the discussion of the paper before the Elektrotechnischer Verein by Dr. Salamon, on the photometry and marking of electric lamps—a subject with which we, in this country, have been recently occupied. The author gave a series of polar curves from lamps having various forms of filaments, drawing the conclusion that the only rational method of estimating the light is in terms of mean spherical candle-power. He also advocated that the consumption in watts should be marked on the lamps. On this point there was much discussion, some speakers expressing the view that mean spherical candle-power should also be indicated. Professor Wedding showed himself again a strong advocate of mean spherical candle-power, pointing out that in these days it is possible to alter the distribution of light from a lamp very widely by means of appropriate globes and reflectors, and that it is often necessary to modify considerably the direction of light from one and the same lamp, according to the purpose for which it is used. Professor Wedding wished to apply this basis of comparison to all illuminants, and not only to glow lamps, and he added that

* Sept. 1915, p. 393.

recent experiments on the Ulbricht globe had demonstrated the utility of this apparatus for measurements of spherical candle-power.

Some speakers were in favour of only marking the watts on the sockets of lamps, but advocated the giving of full data regarding candle-power and distribution of light in catalogues and price lists. Others, however, wanted to mark on the lamps much fuller information, including P.D., watts, efficiency, and mean lower hemispherical candle-power. Dr. Bloch agreed in principle that mean spherical candle-power was now the correct method of comparing the candle-power of lamps, and theoretically should be applied to all illuminants. Nevertheless, he had come to the conclusion that it would not be acceptable to makers of arc lamps, and thought that it would be necessary to make a start with glow lamps first. He also considered that from a practical standpoint it was desirable to mark lamps with the watts, and pointed out that at the present time, when lamps consuming 1 watt per H.K. were in general use, it was a convenient moment to take this step. He suggested also that in view of this fact there should be a reversion to the more scientific method of expressing efficiency in "candle-power per watt."

Prof. Wedding, in the remarks quoted above, had referred to the experiments of the Lichtmesskommission of the Verband deutscher Elektrotechniker on the use of the Ulbricht globe. These experiments are summarised in an article by Utzinger, who gives precise particulars for the coating of the interiors of such apparatus. He proposes two distinct coatings, one to form the permanent ground work, the other, consisting mainly of zinc white, to be superimposed over it and preferably renewed every year.

ILLUMINATING ENGINEERING IN AUSTRALIA.

WE notice with interest a lecture on artificial lighting which was recently delivered by Mr. V. H. Mackinney before the Electrical Association of

Australia (N.S.W. Section).* The ground covered in the paper is familiar to readers of the ILLUMINATING ENGINEER. Mr. Mackinney gave some examples of the value of good lighting in connection with the care of health, and as a safeguard against accidents. He summarised the general points to be attended to in order to give a pleasing and comfortable impression to the eye, and he showed a number of illustrations which had previously been brought before the Illuminating Engineering Society in this country; these included some of the pictures of shadow effects for which the author was responsible in connection with Mr. J. S. Dow and Mr. J. G. Clark. A special section of the paper deals with the control of light and the application of suitable forms of globes and reflectors to artistic designs of fixtures.

We are glad to see that in spite of the distraction of the war, illumination is being studied in Australia; no doubt when peace is restored there will be opportunities for considerable development in this country.

A UNIQUE MOVING PICTURE EQUIPMENT.

IN *Popular Mechanics* (August, 1915) there is an account of a special moving picture installation now being used in the Chicago amusement parks which enables pictures to be shown in the open at night without being interfered with by the glare of the numerous incandescent lamps and arcs used to illuminate the grounds.

The picture is projected from a distance of 186 feet on a specially chemically prepared translucent screen. The projector is behind the screen, so that the picture is seen by transmitted light. In this way a much brighter picture is obtained. The only screening consists of a series of radiating black curtains near the sheet, which do not interfere at all with the view of the audience seated in the open.

* Reproduced in *The Salon*, the official organ of the Institute of Architects of New South Wales, Queensland, South Australia, West Australia, and Tasmania, April, 1915.

A NEW FORM OF FLICKER PHOTO-METER.

THE comparative advantages of Equality of Brightness and Flicker Photometers have been much debated, and there is much to be said for an instrument capable of utilising either of these principles. H. F. Kingsbury has devised an attachment enabling the Lummer-Brodhun photometer to be used as a flicker instrument. The observer looks at the photometric field through a small aperture subtending about 2° at the eye. (This size of aperture is selected because—according to Ives—if the field subtends this angle and the illumination of the photometer screen has the convenient value of about 25 metre-candles, flicker and equality of brightness photometers give the same result.)

By means of a rotating prism in the observation tube the two illuminated surfaces in the photometric field are brought successively in front of the aperture, so that a flicker results. In this way we make use of the very fine line of division between the photometric surfaces characteristic of the Lummer-Brodhun photometer. A very sensitive arrangement is thus secured.

One interesting refinement mentioned by the author is the illumination of the eyepiece, which has a whitened interior, by means of a small concealed glow lamp. In this way a luminous area surrounding the photometric aperture, having the same degree of brightness, is secured. It is suggested that this has a more satisfactory and less fatiguing effect on the eye than the usual contrast between the bright luminous field and the dark tube around it.

The problem seems to be somewhat similar to that encountered in rifle range lighting, where the severe contrast between the brightly illuminated target and the very dark surroundings was found to be sometimes unfavourable to acute vision.

THE IMPORTANCE OF BACKGROUND IN THE OPERATING THEATRE.

AN interesting point in connection with the design of Operating Theatres was raised in a recent letter to the *Lancet* by Sir Berkeley Moynihan, Head Surgeon to the Leeds Infirmary. To the illuminating engineer the importance of careful design of the lighting arrangements in an operating theatre is evident; it is essential that the principle of "light on the object and not in the eye" should be followed and that there should be no tendency to glare through exposed lights.

Sir Berkeley's letter, which we reproduce below, shows that the nature of the background may also have a decided influence on the operator, and that if the surroundings are too light they may give rise to a species of glare which it is desirable to avoid:—

SIR,

It has long been the custom of surgeons to use white sterile towels or sheets around the area upon which an operation is to be done. There are many disadvantages in the use of white. A large expanse of white, especially when the sun is shining, is wearisome to the eye and causes fatigue, and it detracts from the value of the light upon and within the wound. It is not sufficiently realised that good illumination is not needed, except upon the part which is concerned in the operation. Light should be concentrated upon the wound and not widely diffused. For the last two years and a half I have used towels and sheets of green colour instead of white. Green is a restful colour, offers no sharp contrast to the colours of the wound surfaces, and allows ligatures and sutures to be clearly seen against it. I have tried black towels, but the change from black to other colours in an operation theatre is sudden and trying, and ligatures do not stand out clearly against such a background. I have painted the walls of my operation theatre green, and have a green coloured material on the floor. The great relief to the eyes which results from the use of a green material round the wound is remarkable. The ordinary green "casement cloth" from which my towels and sheets are made is of good colour, retains its colour on washing and sterilising, is easily obtained and is cheap.

I am, Sir, yours faithfully,

(Signed) BERKELEY MOYNIHAN.

NOTES ON LONDON'S LIGHTING DURING THE WAR.

SINCE the diminished lighting of London came into force there have been many interesting and occasionally amusing references to the subject in the press. Few days pass without one noting some mention of lighting. The changes have certainly done a great deal to interest the public in street illumination—and, we may hope, to convey some lessons which will be acted upon when once we return to normal conditions.

Whitened Kerbs—and Constables.

In the last issue of this journal the most recent Lighting Order was summarised. Reference was made to the practical suggestion that the kerbs and street refuges should be whitened. The steps taken in this respect have already been of considerable assistance to those groping their way home in the gloom.

According to the latest news, it appears that not only stationary obstacles, but moving animate ones, are also to be whitened. In future constables on point duty will wear a broad white band above the left cuff. This, no doubt, will make the uplifted arm more visible. The method is curiously similar to one adopted in America, and described in the last issue of *THE ILLUMINATING ENGINEER*.

It goes without saying that the changes have had a marked effect on the life of London. People stay at home to a much greater extent, and it is said that a "national campaign" to popularise reading is to be instituted. Meantime churches are considering the advisability of discontinuing evening service, and this step has already been announced at St. Paul's. Leading shops are also to close earlier, in some cases at 5 o'clock.

The condition of the streets by night has been the subject of recent discussion, both in the House of Lords and in the House of Commons. Sir William Byles is reported to have expressed the hope that late sittings of the House would be restricted. "Some of them (the members) were getting old and deaf and partially blind, and the condition of the streets now made it a dangerous operation for them to traverse them late at night."

Illumination during a Fog.

Lord Sydenham, in the House of Lords, said that, with "respect to illumination he thought we had gone perhaps a little further than was necessary in the direction of darkening our streets. If the illumination were kept low enough to prevent the identification of special objects, that was as low as it was necessary to go." Moreover, flashlight signals from possible enemies in our midst were rendered easier if the illumination were diminished beyond a certain point.

The difficulties of traversing the streets were made still more evident during a recent fog, and on this point also Lord Sydenham had something to say. He thought that when fogs occurred temporary lighting measures, at any rate in the main thoroughfares, should be provided. Lord Curzon, in reply, indicated that arrangements had been made to turn on, in foggy weather, a number of lights which were not used on clear nights. Another step to be taken was the provision of flares at important points of traffic.

Special Speed Limit for Motor Vehicles ?

There has also been much discussion on the desirability of imposing a special speed limit for vehicles. This matter came before the London County Council, but it appeared the Act contains no provision for imposing such a limit within certain hours only; on the other hand, the imposition of the limit at dangerous crossings and important stopping places at all hours would be difficult to enforce, and could only be obtained by application to the Local Government Board.

Meantime accidents ascribed to the reduced lighting continue to occur. Take, for example, in a recent inquest at East Ham on a cyclist who collided with a taxicab. The jury, in returning a verdict of accidental death, said it was mainly due to reduced lighting, and the Coroner said that the man had been sacrificed to the needs of the war in the same way as others had been sacrificed at the front. A motor-bus accident, which occurred shortly before midnight in Westminster Bridge Road on November 7th, and resulted in the death of one man and the injury of two others, may

also have been due to the present conditions, as the street was stated to be very dark at the time.

Wanted—A Definition of "A Bright Light."

Drivers are still faced by the problem of deciding what constitutes an unduly bright lamp. An amusing incident is narrated in the *Evening News* for November 1st:—

A motorist was stopped by a "special," and the following monologue took place:—

"Your light's too powerful. I shall have to report you. I don't want any arguments. . . . Where's your license? . . . Thank you. What's the name on it? (Attempts to read license by light of offending lamp). . . . 'Er—just turn that light up a bit, will you!'"

The problem likewise occurs in connection with the regulations for screening lamps in shops and houses, and there seem to be remarkable variations in the fines inflicted for this offence in different neighbourhoods. Perhaps the most remarkable among the definitions of a bright light furnished by the war is that given by a magistrate in the case of a costermonger, summoned at the South Western Police Court for not subduing the bright lights of his wheel stall.

Defendant wanted to know what a bright light was.

"A bright light," said the magistrate, "is a light that is bright. It is a relative term."

We can scarcely hope that the poor costermonger felt much enlightened.

CORRESPONDENCE.

DIMINISHED STREET LIGHTING AND MOTOR TRAFFIC.

18th October, 1915.

SIR,

Now that our streets are so exceedingly dark at night, may I be permitted, through your columns, to beg pedestrians, for their own safety, not to walk along in the roadway, so long as there is a reasonably good path alongside which they can use?

I am a motor-cyclist, engaged on Government work at Woolwich, and every night in the course of my 6-mile journey home I pass a considerable number of people walking along in the roadway, quite regardless of the fact that they cannot be seen by approaching traffic. It would appear to be a prevalent idea among pedestrians, who probably have not seriously considered the matter, that a motorist's lamps still enable him to see objects some way ahead of him; but I would point out that this is not the case at the present time, no matter how slowly he may be travelling. Khaki is especially difficult to see at night.

Driving home every night through almost unlighted streets, after long hours at work, is already quite enough strain for one's nerves, without the added danger of unlighted pedestrians walking along in the road. If a man specially

desire to walk in the road, I should suggest that he carry in his hand something white, such as a paper or a handkerchief; though even this would be almost invisible, it would be better than nothing at all.

May I also appeal to drivers of vehicles of all kinds, horsed ones especially, to have lamps on *both* sides in front, with a *separate* red lamp at the rear? The usual off-side lamp with a red glass at the back is quite invisible from behind, if the road curve slightly to the left; in many cases, too, such a light is obscured by the rim of the wheel or by an overhanging load, though technically a red light is there. At a cross-roads, if only the one front lamp be carried, a vehicle is quite invisible to any one approaching from the driver's left. Further, lamps on vehicles should be placed at a reasonable height only, as on a car or taxicab. One frequently meets vans or lorries with their lamps placed very high up—motor-buses also being great offenders in this respect—with the result that unless one be on a very familiar road, it is very easy at a distance to mistake their lights for those of street lamps.

Yours, &c.,

A MEMBER OF THE
ILLUMINATING ENGINEERING SOCIETY.

SOME NOTES ON LIBRARY LIGHTING.

By ALEX. J. PHILIP.

(Editor of the *Librarian and Book World*.)

A CERTAIN looseness is to be observed in the general use of terms in lighting, although a degree of standardisation is being adopted gradually. Where those discussing the subject are experts this does not matter very much, because, even if the misconception is not admitted, the one very quickly sees what the other understands by the term. This is not the case in general, and for this reason the terms "point," "general," "reflected," "diffused" will be defined in their use here during the progress of the paper.

"Point" is the point at which the light is thrown. There may be several lamps at that point, which would be described as a cluster. The "point" in wiring is the spot at which the wires emerge or are fixed. From this has grown up—in libraries—a slightly different use of the term, due entirely to the somewhat peculiar conditions of arrangement, but the term when analysed, is exactly the same in meaning. This can be best explained by describing the point lighting of a quadruple newspaper stand. The wires emerge from the floor at one point and are carried up a leg of the stand; there they are divided into four points, or individual lamps: *i.e.*, one over each newspaper on the stand. This is in no sense a cluster as there is a space of from 2 to 3 feet between each lamp. There is much to be said in favour of point lighting: and in certain departments of public libraries it is almost essential. Purely point lighting has the disadvantage that above the eye-line the light in the room is dim, unless the number of lamps is very large and the shades are transparent: under these conditions many of the features of combined point and general illumination are to be found. And here it may be said that in general point lighting for public institutions must be used in conjunction with some other system.

General lighting, from the library point of view may be described as a distribution of light by means of arc

lamps, single powerful wire lamps, or clusters of lamps, at a height greater than that of any possible eye-line, and without either concentration or diffusion of light. It may be said at once that this method has very little to recommend it for either libraries, museums or art galleries, except its economy and from the standpoint that it "looks nice" from outside. On the other hand a small amount of general illumination combined with point lighting may be made to yield excellent results.

Reflected light consists, in principle, of throwing a strong shaded light on to a large white surface such as the ceiling or the upper parts of the walls. The light that is thrown back or reflected—sometimes called diffused—is soft and evenly distributed. It is, undoubtedly, the nearest approach to natural light. It is not particularly adapted to book stacks; and is, moreover, very expensive when compared with, say, general illumination. But for art gallery, and museum work, and for most departments of library work it is unsurpassed.

The impossibility, on the score of expense, of installing reflected light, has brought into vogue the system known as diffused light. This may be best described as a combination of "general" and "reflected" systems. One big lamp, or a cluster of smaller lamps set in a shallow shaded, or ground, or frosted glass bowl throws beams on to the ceiling and from the ceiling downwards. If the ceiling does not offer a suitable reflecting surface a reflector is arranged over the bowl.

A public library presents more problems in lighting than any other library, and in dealing with the problems of a public library most of the difficulties experienced in private and institutional libraries are met with.

The lighting of the Reference Library presents many special difficulties, largely because there are various eye-lines. This is the result of placing tables and

bookcases in the same room. Without the bookcases the room becomes a reading room: without the tables it is a bookstore. As a rule some of the bookcases are open for the use of the public; while others contain books to be obtained only on application, but are so shelved, that the public are not only able, but expected, to read the titles on the backs. These bookcases are usually from 7 to 8 feet in height. The line of vision may be therefore nearly 8 feet from the floor, while the eye-line on the tables may be as low as 3 feet 6 inches. The bookcases and tables are usually dark in colour; more often they line the wall, less frequently they project at right angles. Under these circumstances the best system has been found to be a system of diffused lighting supplemented by small candlepower lamps for point lighting. The advantages are still more marked where students' tables are in use. The table lamps may or may not be arranged for switching on and off by the reader. The fascination of table switches in many cases is only that of a toy. Their use is a confession that the reference library is not expected to be much used. Where table switches are installed there must be sufficient light not controlled by the readers. The British Museum is often cited as an example of the value of the table switch; but the British Museum is almost unique in the enormous height of the dome and the distance of the arc lamps from the floor; as well as in the class of reader using the room. Under no circumstances should one light or a single switch serve two readers. If the bookcases in the reference room are low in height and few in number they may be illuminated with point lights also.

In point lighting particularly a great deal depends upon the shades. Since the introduction of the long metal filament lamp shades have not changed sufficiently in size and shape. On the eye-line nothing of the naked lamp should be visible. Many of the cup-shaped shades are not deep enough to prevent the rays from the lamp shining directly into the eyes of the reader. One of the most useful shades in a library is the inverted cone shape of 6 or 6½ inches deep and 10 inches in diameter. The

reason for this is to be found in the greater radius of the effective beams of light without the lamp itself becoming visible. The height of the lamp from the table is determined by the size of the table and the power of the lamp. It is a *sine qua non* that the shade contains the whole of the lamp. The question of standard versus drop lights over tables is determined in general by the size of the table. Small, and single tables, may be fitted with standards because the circle of the reading surface can be covered by the reflecting shade a short distance above. If the table is bigger than the circle of effective light two lamps must be used if standards are insisted upon. There are several disadvantages in the use of table standards, but, perhaps, the most important is that a considerable amount of light is wasted because the rays of both lamps are thrown on the same surface near the centre, and that section is not used for reading purposes. If the standard is high enough to do away with this objection the danger of the direct rays being thrown into the eyes of the reader becomes very great. The drop light, however, can be 3 feet 6 inches above the table reading surface; a height sufficient to remove the danger of direct rays at the seated eye-line level. The circle of effective light from the reflector-shade described is 7 feet. This must be qualified by the lighting power of the lamp. The higher the lamp the greater the radius of light and the lower the illumination. It will be seen, too, that the illumination is less at the outer edge of the circle than at the centre. To put the statement in every-day terms: a 50-watt lamp in a deep opal shade 10 inches by 6½ inches, raised 3 feet 6 inches above the reading surface will throw quite sufficient light on a circle 7 feet in diameter, in conjunction with moderate general or diffused lighting. But by continued experiment it has been found that opal shades used for point lighting allow sufficient light to pass upwards to satisfy the needs of general illumination—if they are in sufficient numbers. In this way all the advantages of point lighting are secured with many of the more prominent advantages of diffused and general lighting at a minimum cost.

These remarks regarding table lighting apply equally to all the reading rooms of a public library.

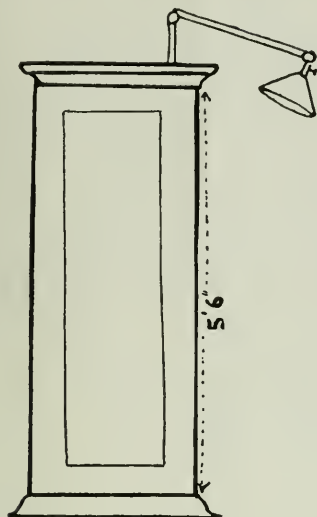


FIG. 1.—Point light for low single bookcase in adjustable holder.

Point lights for low single bookcases should be fixed in adjustable holders. These are to be obtained with any number of joints, but it is seldom that more than three are required. If the bookcases are tall the difficulty of lighting them is much greater; as in the ideal system the lower shelves will be as well lighted as the upper. The more ordinary problem in the extraordinary class is to light bookcases 9 or 10 feet high in a public reference room. These high bookcases are seldom found in lending libraries because the constant demand for books makes their use prohibitive. The ordinary drop light will not illuminate a bookcase of this height sufficiently for public or semi-public use. The farther out and the lower the lamp the less illumination there is on the upper shelves; the nearer and higher it is—to throw on to the upper shelves—the less light there is on the lower shelves. Many plans suggest themselves, but in most cases the reader or user throws his own shadow on to the books. The proposal to place white druggut or similar material on the floor between the cases loses sight of the fact that any such floor covering will become dirty in a

few minutes in an open-access library. Troughs for lights at the foot of the bookcases are open to the insuperable objection that, if the trough is near enough the case to avoid the would-be reader the light is thrown upwards, while if the trough is brought forward, the light is obscured by the readers' boots and clothes. There are still more serious objections to the raised reflector or step at the foot of the bookcases in certain libraries: quite apart from the fact that the continuous step is now rarely met with.

It is not necessary to go into the details of the objections to various schemes: it will be sufficient to describe the method that best solves the problem of the 9 feet bookcase. The very tall bookcase is seldom seen in lending libraries, but the remarks already given refer equally to the lending library where the lighting problem is the same. The special problem of the lending library is in two parts: (1) as an "open-access" library; (2) as a closed library. The lighting in the first case must be much more effective than in the second, although this is not to say that the lighting in the second may be defective. A 50-watt lamp in a shade the size already described hung at the level of the top of the books or the top shelf mid-way between the two cases will be found to throw enough light on both sides of the gangway for a distance of 3 feet on either side, to satisfy the conditions of (2). I quote these shades

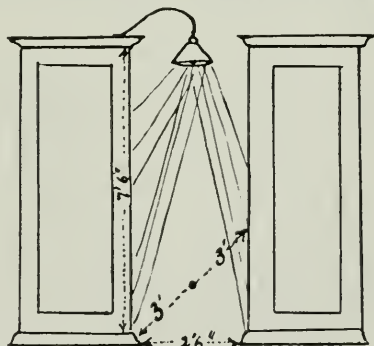


FIG. 2.—Lighting bookcases in a "closed" library.

because they are a definite standard giving certain universal results except for local variations, but other designs may be

used giving brighter or softer lights; or contracted or extended reflection.

In a "closed" library (2) local switches are recommended.

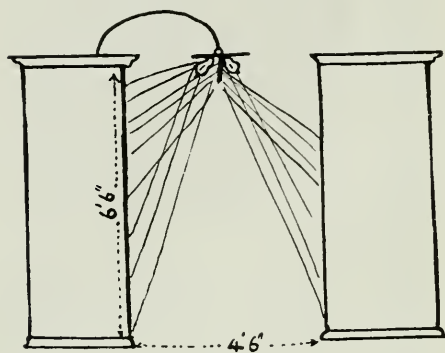


FIG. 3.—Small c.p. lamps for open-access libraries.

We come now to the "open-access" library. The bookcases here are not more than 6 feet 6 inches high, nor less than 3 feet 6 inches apart. The arrangement of lamps suitable for the tall bookcases is quite unsatisfactory here. The body of the reader must always interpose between the light and the books. The use of double lamps of small power, say 30-watt or 50-watt, and reflectors of the shape shown in the sketch below, or some shape equally suitable will go a long way towards solving the problem. If economy is essential the following shape may be used; but the result is not so satisfactory. The shade-reflectors may be of porcelain or white enamelled metal.



FIG. 4.
Bare lamp.

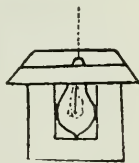


FIG. 4A.
Suggested form of shade.

Another method, successful so far as lighting is concerned, has the drawback that the light is thrown into the eyes of the readers at certain angles, although this evil may be reduced by using frosted bulbs: in a double bookcase the lights, small in power, are shown in box reflectors at alternate corners; the lamps on the bookcases opposite would be reversed in position. The

principle of this is that each case is lighted from the case opposite.

The most difficult section of the closed library is that containing the Indicators. These present a flat perpendicular glazed surface on the one side, and a similar surface on the other, unglazed. They are about 3 feet 6 inches high and about 3 inches thick, although a wooden frame increases the thickness considerably. Drop lights are a failure. The only satisfactory method so far is to use fixed standards with adjustable joints. Lamps on the glazed side should not be very powerful on account of the reflecting surface, and they should not be more than 4 feet apart.

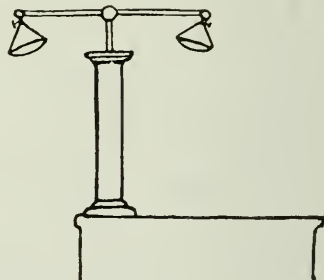


FIG. 5.—Adjustable lamps over an indicator.

Catalogue tables, slopes, or stands, and card catalogues are so infinite in variety that it is extremely difficult if not quite impossible to deal with the subject satisfactorily in a few words. If efficient diffused or reflected light is provided no further special treatment will be required in most cases. Owing to the peculiar conditions governing many forms of slope and stand for catalogues the drop light is seldom entirely successful, except in such circumstances as are to be found in the British Museum, where the catalogue cases would be governed by the remarks already made on table lighting. The simple wall slope, however, that is to be found in some libraries, should have the lights arranged at the back, a few inches above the catalogues, set length-ways in long reflectors.

The combination of news-room and reading-room generally results in misfortune if an endeavour is made to make one system of lighting satisfy the requirements of both. This is shown in the following figure. The maximum light

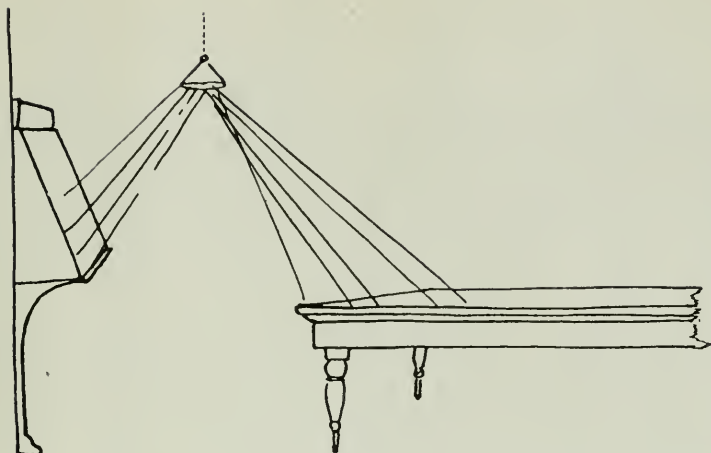


FIG. 6.—The maximum light is thrown on the floor.

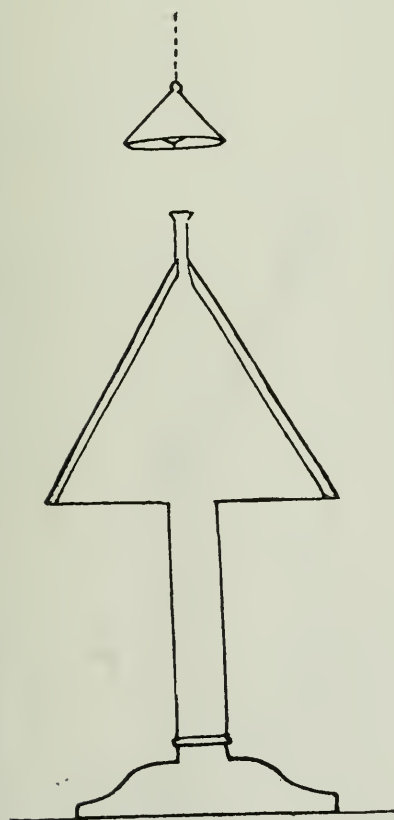


FIG. 7.—The light in this case is wasted and badly distributed.



FIG. 8.—The reader here throws his own shadow on the paper.

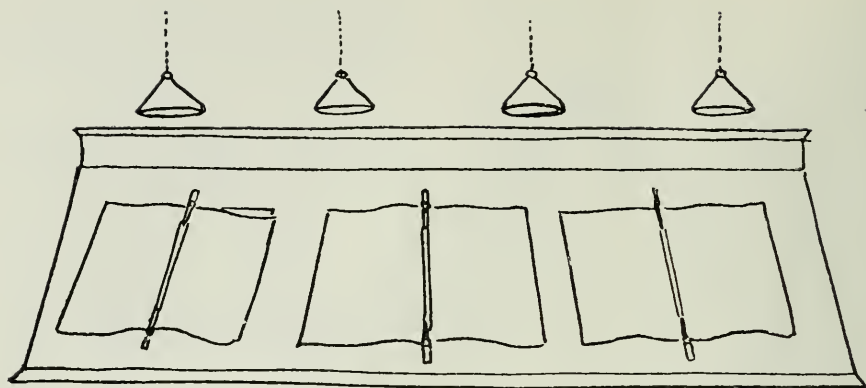


FIG. 9.—The maximum light in this case is thrown on to the stand, not on the paper.



FIG. 10.—The circle of light is too small and too concentrated.

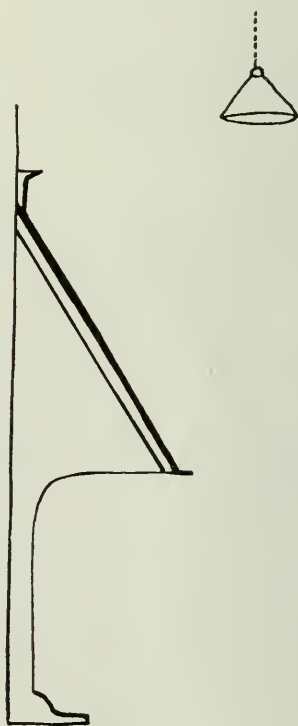


FIG. 11.—The upper part of the paper is in the shade,

is thrown on the floor. The needs of both news-stands and reading tables must be considered separately. Tables have been dealt with already. The newspaper stand or "slope" presents a surface at an angle of from 50° to 60° . The type is small, as a rule, and several persons may be using the paper at the same time. On the other hand if each paper has its own light the surface to be illuminated is not more than 5 feet by 3 feet. Figs. 7 to 11 show arrangements to which serious objections can be urged.

Long experiment has shown that the method of Fig. 12 is the most successful for the following reasons:

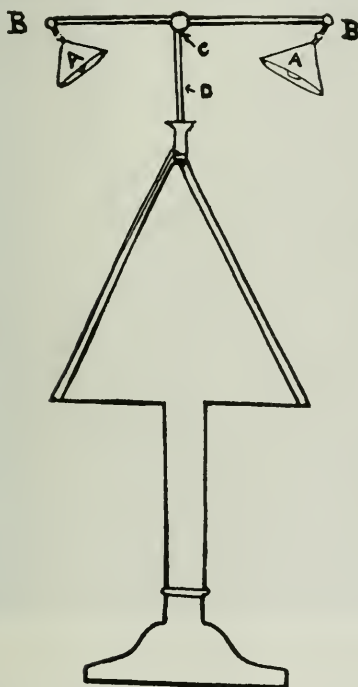


FIG. 12.—An effective method of lighting newspaper stands.

direct rays cannot shine in the eyes of the reader; the reader cannot intercept the light; low candlepower lamps may be used as the maximum illumination is on the paper; the whole of the newspaper is illuminated.

A.A. are the shades 10 inches by $6\frac{1}{2}$ inches already described (the size is the important point),

B.B. Adjustable ball socket with thumb screw.

c. Centre tube in an outer tube, fixed with a thumb screw.

D. Tube in which "c" works up and down.

The variation of height is a maximum of 18 inches. The whole revolves when desired. And the lamp can be adjusted at any angle for large or small periodicals.

In the lecture hall, now attached to so many libraries, a form of reflected or diffused light is to be recommended. In view of the fact that at some time or another the hall is likely to be used for exhibitions — photographs, pictures, museum objects, or business appliances — this might be described as almost essential, because no system of point lighting could be devised capable of being adapted to the varying conditions of miscellaneous exhibitions. If the use of the hall is to be strictly limited to lectures, "general" illumination may be adopted. The arrangement of the light points and switchboard should be governed by the lantern lecture, *i.e.*, by the need for controlling all the room lights from one board, with alternating switches for certain lights at the doors, with an individual switch for the lecturer, and an independent switch for the lantern. The staff room, workroom, and committee or boardroom do not present many special problems other than those to be met with in houses of business everywhere; the same applies to the librarian's office.

The librarian's office and the committee room should offer no difficulty to the introduction of diffused or reflected light, although the former should have a drop light with a counter-weight for minute scrutiny of doubtful material or microscopic examination. From the desk it should be possible to control all the lights in the office by alternative switches. In store rooms it is a good plan to have a minimum number of fixed lights with plenty of movable lamps. If the work room is extensive and used for book-binding, repairing, printing, mounting, cataloguing, classifying, &c., each part of the room must be treated according to the work to be done there.

PROFESSOR VIVIAN B. LEWES.

BORN 1851—DIED 1915.

IN the death of Professor Vivian B. Lewes, who passed away on October 23rd, the gas industry has lost one of its leading exponents. Professor Lewes was a man of varied scientific attainments, and for half a century had been associated with applied chemistry, particularly in relation to the industrial uses of gas and oil fuel.

His first appointment, in 1879, was as assistant to Prof. Williamson, the chief gas examiner in the Metropolis. Subsequently he became Professor of Chemistry at the Royal Naval College, Greenwich, a post which he filled until a few years before his death. In 1892 he was also appointed superintending gas examiner for the City of London. His active mind interested itself in many varied controversies of the day, and he contributed many papers to scientific societies.

It was, however, as a lecturer that Professor Lewes found his special sphere. He had a remarkable gift of clear explanation and never failed to interest his audience, often driving home his point by apt illustration and humorous anecdote. Probably few lecturers of our time have spoken on such a variety of platforms, but his discourses before the Royal Society of Arts were perhaps the most widely known. His celebrated series of Cantor lectures on Acetylene, from which afterwards came his book on this subject, and on the Incandescent Mantle, were of European reputation and are still widely quoted.

Throughout his life Professor Lewes



Photo by Elliot & Fry. For the use of this block we are indebted to the courtesy of the "Journal of Gaslighting."

took a great interest in lighting matters and delivered many popular lectures on this subject. He was one of the original Vice-Presidents of the Illuminating Engineering Society. Shortly after the commencement of war he became Chairman of the Chemical Section of the Inventions Department of the Ministry of Munitions, and but a few weeks ago lectured on Explosives before a crowded audience at the Royal Society of Arts.

His death will be keenly regretted by many friends in this and other countries.



TOPICAL AND INDUSTRIAL SECTION.

— . . . —

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]



OSRAM PAINTING BOOKS.

The General Electric Co., Ltd., have certainly struck a novel and enterprising method of advertising in their "Osram painting-books" for children. Throughout there are coloured pictures on the right-hand side and corresponding line pictures to be filled in on the left. The first of the series of three books before us deals with the lights of 1830, 1890, and 1915—candle, gas, and electric light. Another book deals with the illuminating engineering efforts among the Eskimos, the incidents being illustrated by quaint pictures in the orthodox picture-book style, and simple verses. On the cover there are some sound hints to aspiring young artists, while parents are advised to use Osram lamps!

PORCH LIGHTING.

More than once in this Journal reference has been made to the problem of lighting the porches of private residences, so as to show up the steps at night and enable visitors to depart without the risk of a fall.



SIEMENS CONTRACT.

Messrs. Siemens Bros. Dynamo Works, Ltd., inform us that they have received an acceptance of a tender for the supply of Wotan lamps to the G.P.O. for the ensuing six months.

THE WOTAN METAL DESK PAD.

We have received a specimen of the simple and ingenious Wotan desk pad, which acts both as a letter-weight and as a tablet for memoranda. The pad is provided with a spring clip so that any sheet can be readily detached or replaced as occasion requires.

The adjacent illustration shows a case in which the chief requirements seem to have been met. The stairs are lighted by a lamp in a Holophane Bowl, mounted on the ceiling of the porch, so as to be outside the direct range of vision and to throw the light down on the stairs.

It will also be noted that the pillars are shown up in strong relief, and the general effect is quite pleasing.

THE LIGHTING OF WEST AFRICAN HOUSE, KINGSWAY.



View of the general office lighting, West African House, Kingsway.

The chains suspended from the fittings are used to actuate the three-way switches.



Agent's Office, West African House, Kingsway.

Above are two examples of the British Thomson-Houston's Company's "Eye-Rest" indirect lighting system as installed at the new West African House,

Kingsway, which utilises some 120 "Eye-Rest" fittings. Attention is drawn to the excellence of the diffusion of light and its restful effect on the eyes.

EDISWAN ARTISTIC LIGHT FITTINGS.

The New Ediswan Catalogue of Artistic Light Fittings (Section VI.) is now to hand. It covers all the usual

range of units employed for interior and domestic lighting, hall lanterns, pendants and ceiling fittings, table standards, piano and reading lamps, &c.

The most striking sections are, perhaps, those on ornamental brackets and semi-indirect fittings. The latter are unusually complete, and we notice that the effective method of presenting these fixtures with a black background, is adopted. We reproduce two blocks showing respectively typical semi-indirect and bracket units.

Two graceful designs of Newell Pillars also deserve mention.

THE LIGHTING BOOKLET.

We have received from the Holophane Works of the General Electric Co., of Cleveland, Ohio, a copy of the "Lighting Handbook"—a little publication giving much information in a condensed form. Besides the usual definitions of lighting units, and tables of illumination required for various purposes, we notice some tables illustrating the appropriate spacing of indirect and semi-indirect units—which is less well known than the corresponding particulars for direct lighting. Speaking generally, indirect and semi-indirect units may be spaced at a distance apart equal to $1\frac{1}{2}$ —2 times their height, according to the size of the room for general lighting; and at distances apart equal to .5—1 times their height if a strong illumination for detail work is aimed at.

Various problems in lighting are briefly dealt with, and in conclusion the polar curves and data for a representative series of units are given.



REVIEW OF BOOK.

Jena Glass and its Scientific and Industrial Applications. By Dr. H. Hovestadt; translated by J. D. and A. Everett. (Macmillan & Co., London and New York. 1902. 419 pp.)

THERE has probably never been a time when the people of this country were more ready to appreciate the value of science in industry; and one could scarcely select a better example of highly-specialised applied science than the glass works at Jena, whose development is described in the introduction to the above volume. In this field, as in so many others, early enterprising efforts were made by individuals in England—for example, Harecourt's efforts extending from 1834 over half a century. But the scientific development of the glass-making really began with the researches of Abbe and Schott and their experimental work at Jena from 1882 onwards.

It is only possible to give a brief survey of the highly technical matters discussed in this volume. The headings of the chapters are as follows:—

I. Introduction; II. Optical properties of glass; III., IV., V. and VI., Perfecting of optical systems by the new glasses; the microscope, photographic objectives, telescopes, &c.; VII. Mechanical properties of glass; VIII. Thermal properties of glass; IX. After-working and thermometry; X. Chemical behaviour of glass surfaces; XI. Electric and magneto-optic properties of glass.

It is only necessary to glance over this list to appreciate the value to science of such work, as well as its industrial importance. Long years of research were necessary in order to produce series of glasses whose index of refraction, density, and dispersive power are accurately known, and which in addition have mechanical and chemical properties

which render them specially adapted for various scientific instruments.

The book brings together information from many sources not readily available to the ordinary reader, and at the present moment the whole subject is one of vast importance, both to the optical and the lighting industry.

PERSONAL.

WE learn with regret of the death of Mr. F. H. Gooch, who was on the staff of Messrs. Drake and Gorham, but joined the Cameron Highlanders soon after the outbreak of war. He fell in defending a German trench which our troops had taken in front of Vermelles.

Mr. Gooch was a member of the Illuminating Engineering Society, and was greatly liked by all who knew him.

Established
1885.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.

Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES

Of Life Assurance, with Various Options

All Classes of Insurance Business Transacted

CHIEF OFFICES:

General Buildings, Perth, Scotland.

General Buildings, Aldwych, London.

General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, November, 1915.

	PAGE
Correspondence (Diminished Lighting and Motor Traffic)	464
Daylight Illumination in Schoolrooms	457
Editorial by L. GASTER	441
Electric Incandescent Lamp, Development of	456
Factory Lighting, A Code on (<i>continued</i>)	451
Flicker Photometer, New form of	462
Illuminating Engineering, A Year's Progress in (<i>continued</i>)	445
Illuminating Engineering in Australia	461
Illuminating Engineering in Germany	460
Illuminating Engineering Society (U.S.A.): A Series of Lectures on Illuminating Engineering	457
Lewes, Professor Vivian B. (Obituary)	472
Library Lighting, Notes on, by ALEX. J. PHILIP	465
Lighting of London in War Time, Notes on	463
Operating Theatres, Background for	462
Sale of Gas in the United Kingdom, Present Practice in, by F. W. GOODENOUGH	458
Topical and Industrial Section:—	
Porch Lighting—Osram Picture Pook—Siemens Contract	473
B.T.H. Office Lighting	474
Ediswan Fittings	475
Review of Book (Jena Glass, by H. HOVESTADT)	476
Insurance Coupon	477
Church Lighting in War Time	478

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL

ACCIDENT FIRE AND LIFE

ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.

GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.

F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

LIGHTING OF A CHURCH IN WAR TIME.

WE are indebted to the British Commercial Gas Association for the accompanying illustration, showing how the lighting of the church of All Saints', Maidstone, has been adapted to war conditions. At the present time the

to meet the situation by the use of suitable shades. The church of All Saints' was formerly lit by eight standards in the nave, each carrying seven upright incandescent burners fitted with pink eye-screens; these illuminated the church brilliantly right up to the roof.

In order to comply with the regulations of the authorities, The Maidstone Gas



Lighting of All Saints' Church, Maidstone, in War Time.

lighting of places of worship is often a rather troublesome problem. In view of the large window area exposed it is important to restrict the lighting so as to make the building inconspicuous to hostile aircraft -- particularly at Maidstone, which, being in an eastern county, is decidedly within the war zone.

The expense of providing blinds for all the windows is, in most cases, a considerable item, and therefore it is desirable

Co. were compelled to modify this system. The standards were accordingly altered to carry three inverted burners with green glass shades, while the brackets on the wall directly under the window carry only one inverted burner fitted with a shade of aluminium.

The present method of lighting, while subdued and adapted to war conditions, is sufficient for the needs of worshippers. No light is visible from outside through the windows.



THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.

32, VICTORIA STREET, LONDON S.W.

Tel. No. 5215 Victoria.

EDITORIAL.

The Health of Munition Workers and Industrial Fatigue.

On pp. 485-506 readers will find the account of the discussion at the last meeting of the Illuminating Engineering Society on the Report of the Departmental (Home Office) Committee on Factory Lighting. As we have dealt with this matter previously at some length, and as the various points raised in the discussion are replied to by the author on pp. 504-506, it is unnecessary to say much more on the subject now. The discussion was very timely, and quite showed the desirability of a general interchange of views at the present stage.

In the future it must be our task to ensure that the matter is kept well to the front and that problems at present unsolved receive attention, and we do not doubt that the Society will be able to do useful work in this respect.

The conditions of health of munition workers are now receiving a great deal of attention, and we have referred to the work of the Committee now studying this subject. We are glad to see that the Committee, while proceeding with the general course of their investigations, have already shown their activity by the prompt publication of two interim reports dealing respectively with "Sunday Labour" and "Industrial Canteens." Seeing that all such correlated factors affecting the health of workers require to be considered in connection with any detailed researches on the effect of light on health, it is worth while to give some account of the conclusions already reached by the Committee.

These two questions—hours of labour and facilities for refreshment—have long been in the minds of social reformers, and have often come before the notice of Government departments. Anyone who has had occasion to visit factories where special attention has been paid to the workers' well-being, will agree that this care has been well repaid by its effect on the work done.

It is gratifying to note that amongst other recommendations the Committee point out that canteens should be properly lighted, heated and ventilated. These three requirements are now coming to be considered conjointly. The additional value of a canteen, when cheerfully and attractively illuminated, is generally acknowledged. In the kitchens, again, adequate illumination is essential in the interests of cleanliness and for the proper preparation of food; the detection of stale or unwholesome food does not depend only on the sense of smell, but frequently upon changes in the colour of the material. Such changes are a sign of deterioration, and require a good light for their detection.

From his own experience the writer is fully convinced of the good work to be done by industrial canteens, particularly in cases where many of the workers live a long way from the work. A rush home to a hastily prepared meal, and in all kinds of weathers, is not the best preparation for further work, and it is surely preferable that the operator should be able to sit down in leisure to enjoy a good meal on the premises.

As regards the question of seven-day labour, it has long been recognised that intervals for recuperation are essential if the worker is to keep his fitness and alertness of mind and body. In the great emergency which arose in connection with munition work special efforts were required, and in many cases the hours have been extremely long. As an *emergency measure* this was perhaps inevitable in some factories, but it requires little reflection to see how seriously such conditions would react on the national health if persisted in for any length of time. It is therefore only prudence to husband our "man-power," and to avoid at all costs the danger of permanently straining and weakening the physique of operators throughout the country.

We have also before us the Interim Report on the Investigation of Industrial Fatigue presented before the Home Office by Professor A. F. Stanley Kent, of Bristol University. Professor Kent has made experiments with a variety of tests for fatigue; for example, the "Ergograph," by means of which the ability to raise a given weight with the forearm is taken as a measure of muscular fatigue; the diminution in acuteness of the senses of vision and hearing following prolonged work; various devices for testing the time of nervous reaction, such as the time taken to appreciate a given signal; and changes in the circulatory system.

Naturally in a new field like this one finds occasional discrepancies, but on the whole the above methods appear to have well served their purpose of indicating the approach of fatigue. The diminution in acuteness of vision and hearing at the end of a day are especially well marked. In interpreting these results it is necessary to take into account not only the actual diminution in sensitiveness, but also the power of recuperation during the night's rest. Some of the tests show a very marked progressive change in this respect during the week's work, and seem to bear out the Committee's objection to seven-day labour. They also suggest the conjecture whether, in a scientifically planned workshop, it would not be desirable to allow occasional short periods for recuperation during the working hours—a plan that was successfully tried in the United States by the late F. W. Taylor.

Fatigue in Relation to Illumination.

It is interesting at the present stage to inquire whether some method could be applied to record with precision the conditions of fatigue due to unsatisfactory illumination, and to gain evidence on the much disputed question whether some systems of lighting are less productive of fatigue than others.

The foregoing experiments appear to show that fatigue of the senses (including the eyesight) may be caused by the general conditions of work, irrespective of the special effect of labour under inadequate illumination. As far as the test of eyesight is concerned it appears incontestible that the fatigue would be greater if the conditions of illumination were such as to handicap the worker. One would therefore like to see these tests applied throughout certain trades, such as sewing, engraving, printing, &c., which admittedly make a special demand on the eyes, the conditions of illumination being varied but the skill of the operators and the nature of the work remaining identical throughout the operation. There is good reason to think that some useful evidence might be obtained through the eyesight test, but it would be surprising if, with a marked difference in the lighting conditions, it did not, to some extent, produce general fatigue, and thus also give indications by the other tests. One thing is very strikingly brought out by the above tests—the need for extending such experiments over a considerable period of time so that the effect may be cumulative. It is only when the influence of fatigue can be traced progressively throughout the period of work, and the recovery when the work ceases demonstrated, that one can feel sure of being able to draw a conclusion.

An interesting line of experiment in this connection is that undertaken by Professor Ferree in the United States, and illustrated in the recent communication by him and Mr. G. Rand at the Convention of the Illuminating Engineering Society (U.S.A.). Their results are based on the observation of the time during which type appears respectively "clear" and "blurred," when steadily looked at for a given period. We would like to have fuller confirmatory tests by observers before coming to any definite conclusions on the matter, and hope that the subject will be investigated in this country.

Such experiments obviously demand the concerted action of lighting experts and physiologists. We have seen that an actual diminution in acuteness of vision may be caused by prolonged fatigue. To an operator who suffered in this way deficient illumination would doubtless prove especially trying, and might accentuate the defects in eyesight; for the eye, while possessing remarkable powers of adaptation to varying conditions of light and darkness, appears to recuperate very slowly, when once it has been overstrained.

But in addition, overwork appears to dull the mental perceptions, . . . to impair the power of the mind to grasp and interpret the impressions transmitted from the eye to the brain. Hence, it may sometimes happen that a fatigued operator acts as though he did not see properly, even though the mechanism of the eye appeared to the examining doctor to be quite healthy.

These instances serve to show the need for care in drawing conclusions from the examination of workmen, and especially in deciding whether the conditions of illumination are adequate or otherwise for the work in hand.

Modern Office Lighting.

New illuminants naturally give rise to new methods of illumination. The increased range of candlepower and greater efficiency of modern electric incandescent lamps has modified many problems in illuminating engineering.

For example a departure in the methods of lighting large offices and banks has come about during recent years. In the days when only carbon filament lamps were available, local lighting was regarded as essential, lamps on standards being spaced at requisite intervals along the desks, and only a small amount of overhead lighting provided for general illumination. Even at the present time some clerks prefer this old system, which has certain apparent advantages. Many people, particularly those who are advancing in years and whose eyesight is not of the best, prefer a local shaded light strongly illuminating the work but leaving the rest of the room in a comparatively subdued light. On the other hand, the installation of a large number of local lamps at intervals is tiresome and expensive, and is at once upset if the furniture is rearranged. It is also not easy to secure that the lamp is completely shaded and yet to obtain uniform illumination from a source so close to the work; and when heavy ledgers are being handled it is sometimes awkward to have a lamp or standard, liable to be knocked, so close at hand.

Until recently the substitution of a satisfactory general lighting system, instead of these local lamps was impeded by the fact that incandescent lamps of sufficiently high candlepower and efficiency were not available, and that indirect and semi-indirect lighting appliances had not been fully developed. Consequently the illumination on the work resulting from a general lighting system was sometimes insufficient, and the lamps, not being properly screened, gave rise to inconvenient shadows. In a good modern installation 4—6 foot-candles is often provided over the desks where work is done, and 3—4 foot-candles on the counters, and in view of the soft character of the lighting, this should meet requirements.

We observe among the papers at the recent Convention of the American Illuminating Engineering Society an account, by A. A. Duggin and J. B. Jackson, of a large semi-indirect installation in Chicago which seems comparable to the above. The illumination in this case was 6 foot-candles (average), and the brightness of the bowl was only 3—4 times that of the ceiling above. The installation appears to have been planned in a very thorough manner, tests of shadow-effect, deposition of dust, &c., being made as well as measurements of illumination.

It would be premature as yet to say that semi-indirect or indirect lighting is invariably best for office lighting, although having some admitted advantages. Much depends on the style and decoration of the interior, which can do much to relieve the impression of "flatness" which is sometimes ascribed to these methods. When work is only continued for a few hours this effect may not be important, but if long-continued it does seem to have a depressing influence. There is therefore room for skill in the combination of the lighting scheme with the decoration and architectural features of the room, so as to avoid flatness on the one hand or undue contrast on the other.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

SOME NOTES ON

THE FIRST REPORT OF THE DEPARTMENTAL COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts (London), at 8 p.m. on Tuesday, November 23rd, 1915.)

THE first meeting of the Session took place on Tuesday, November 23rd, as stated above, the chair being taken by Mr. F. W. Goodenough (Chairman of Council) during the initial proceedings. The Minutes of the last meeting having been taken as read, the Hon. Secretary proceeded to read out the names of applicants for membership in the usual way.

The Chairman then called upon Mr. Gaster to give the usual summary of events during the vacation.

PROGRESS DURING THE VACATION.

Mr. Gaster remarked that in ordinary circumstances there was usually a record of useful work in connection with international congresses to be presented after the vacation. On this occasion, owing to the war, there was, unhappily, little to be said in this respect. It was, however, satisfactory to note that the Illuminating Engineering Society in the United States was continuing its work as actively as ever, and a series of interesting papers had been presented at the recent Convention at Washington.

Report of Departmental Committee on Factory Lighting.

A most important event had been the issue of the First Report of the Home Office Departmental Committee on Lighting in Factories and Workshops, on which

there was to be a discussion that evening. He felt sure members would appreciate the large amount of valuable information contained in the Report which would doubtless be of considerable value to lighting engineers. He might also draw attention to the Committee appointed by the Home Office and the Ministry of Munitions, now sitting to inquire into the health of munition workers. He was glad to say that an opportunity had been afforded of bringing the claims of good lighting before the notice of this Committee.

The Proposed Increase in Postal Rates.

The suggested increase in postal rates, which was to have come into force last month, had been a matter of some anxiety to technical journals. He was glad to say that, as a result of representations to the Postmaster-General on the part of the Institute of Journalists and other bodies, there would be no alteration as far as the Journal of the Society was concerned.

It might, however, be mentioned that journals issued at longer intervals than a week were still in an anomalous position. They did not benefit by the special rates accorded to daily and weekly publications, and it seemed to him unfortunate that journals carrying out

valuable educational work for the benefit of the country should not receive these concessions. This aspect of the matter had been brought before the notice of the Postmaster-General and would, no doubt, receive his careful consideration.

Lighting Restrictions.

The restrictions on public and private lighting had been the subject of much discussion during the last few months, and almost every day references to the subject appeared in the daily and technical press. A record of some of these comments was being kept for future reference. The difficulty of interpreting many of the vague phrases occurring in some of the lighting orders, and the diversity in the penalties imposed for not carrying out these recommendations in different districts, had been recently pointed out in THE ILLUMINATING ENGINEER.

Members would recall that shortly after the lighting restrictions were introduced a Committee of the Society was formed to discuss the best method of shop lighting in war time, and some suggestions were drafted and placed before the authorities for their careful consideration, and a letter of acknowledgment and thanks had been received.

The Society had also proposed to form a Committee to deal with street lighting and offered the services of this Committee to the authorities, an offer which was renewed when the recent changes in streetlighting were being made. The offer was welcomed, but nothing further has yet transpired. The Society had also placed their services at the disposal of the Inventions Committees of the Ministry of Munitions and the Admiralty in connection with all matters relating to lighting. The Council on Industrial Research had placed the Society on their list and invited its co-operation with regard to suggestions for researches of benefit to the lighting industry.

A Gloss-Tester for Examining Glaze on Paper.

Mr. Gaster also referred to the Report of the Committee of the British Association on School Books and Eyesight, which contained an account of the gloss-tester designed by Mr. A. P. Trotter for testing and standardising the amount

of shiny reflection from paper. It was interesting to recall the history of this instrument. As far back as September, 1913, Mr. J. Daniell, the Hon. Secretary of the British Association Committee, remarked on the need of such an instrument to Dr. Louis Bell, who suggested that Mr. Trotter should be consulted. Subsequently, in May, 1914, a discussion between Mr. Trotter, Mr. Haydn T. Harrison and Dr. Louis Bell took place at the editorial offices of the Illuminating Engineer, and the instrument in its present form was the ultimate result. Previous to this the question of using paper without gloss for text books had been debated in the United States, and at the commencement of the year it had been decided to print the official organ of the Society on paper of this kind. Members would be interested to hear that among the journals tested by Mr. Trotter, our own stands easily first in respect of absence of inconvenient gloss.

In conclusion members would note, with regret, the death of one of the earliest Vice-Presidents of the Society—Professor Vivian Lewes, who had done so much valuable pioneering work on the incandescent mantle and other chemical problems relating to illumination.

At the conclusion of the above address Mr. F. W. GOODENOUGH invited Dr. R. T. GLAZEBROOK, C.B., F.R.S., to occupy the chair during the discussion of the Report on Factory Lighting, and Dr. Glazebrook called upon Mr. Gaster to open the discussion (see pp. 485—496) in which the following joined:—Dr. RENE SAND, Dr. JAMES KERR, Mr. W. R. COOPER, Mr. A. CUNNINGTON, Mr. C. C. PATERSON, Mr. JUSTUS ECK, Mr. LEWIS SOLOMON, Mr. E. T. SWINSON, Mr. G. CAMPBELL and Mr. F. W. GOODENOUGH.

Mr. GASTER briefly replied, and the proceedings closed with cordial votes of thanks to the author and to Dr. Glazebrook for having so kindly presided at the meeting.

It was announced that the next meeting would take place at 8 p.m. on Tuesday, December 14th, when there would be a discussion on Recent Developments in the Electric Incandescent Lamp, from the Illuminating Engineering Standpoint.

SOME NOTES ON THE FIRST REPORT OF THE DEPARTMENTAL HOME OFFICE COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.

By LEON GASTER.

[Introduction to discussion which took place at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.), on Tuesday, November 23rd, at 8 p.m.]

My object in opening this discussion is to bring before the Society some aspects of the First Report of the Departmental Committee on Lighting in Factories and Workshops, and to discuss how we, as a Society, can best give effect to its conclusions and assist the work of the Committee in promoting progress in industrial lighting.

It was thought that at the present stage of the work a general discussion would be of great value both in making the aims of the Report more widely known and better understood and in suggesting possible lines of co-operation in the future.

The Report appeared at the beginning of September. It has no doubt been studied by most of these present, either in the original or in the abridged version published in the *ILLUMINATING ENGINEER*.* There is, therefore, no need for me to attempt to summarise its contents, and I shall confine myself to explaining a few of its main conclusions.

In doing so I should like to make it clear that I am speaking in a purely personal capacity and not as a Member of the Committee.

Preparatory Work of the Illuminating Engineering Society.

The issue of the Report is the culmination of a great deal of steady work on the hygienic aspects of lighting which has been done during the last few years. It would take too long to enter into the history of this movement fully, but those interested will find a summary in the editorial in the official organ of the Society for September.* I feel sure that any one who studies that account will recognise that the appointment of the Committee was not in any sense a sudden

decision, but the result of years of methodical work. I am not one of those who expect sudden results or immediate solutions of great problems. The history of our movement has shown that the best results are obtained by persistent and steady effort and by the patient education of public opinion; and that it is invariably unwise to try to rush through things quickly in the teeth of misunderstanding and strong opposition. The most stable organisations are of slow growth.

The work of our Society since its foundation in 1909 has brought about a great change in the public standpoint in matters of illumination. Ten years ago little appeared in the press on lighting matters and such articles as were published usually dealt exclusively with the comparative costs of rival systems of illumination. It has been part of our work to raise other important issues of common interest to representatives of all illuminants, to encourage people not to think only of their expenditure on lighting, but to recognise that lighting is always uneconomical unless it carries out the purpose in view. In particular our Society can take credit for having done much to establish the value of good illumination in the interests of health, and as a practical necessity for the carrying out of work in safety and comfort.

Previous Investigations on Industrial Lighting.

Naturally, this aspect of lighting has been largely responsible for the appointment of the Committee. The need for our investigation was justified by investigations carried out by the Factory Department of the Home Office for several years, much of which has appeared in the Annual Reports issued by H.M. Chief Inspector. In addition

* *Illum. Eng.*, Sept., 1915.

the hygienic aspects of lighting in relation to industry were prominently brought forward at two most important recent international congresses, the *Congres International des Maladies Professionnelles*, held in Brussels in 1910, and the *First International Congress for the Prevention of Industrial Accidents*, held in Milan in 1912, at both of which I was present as a delegate from the *Illuminating Engineering Society*. Shortly after the Brussels Congress a Committee with similar functions to our Departmental Committee was appointed by the French Government, and the American *Illuminating Engineering Society* has also been active in studying the subject and in encouraging appropriate legislation on the part of the various States.

Legislation of other Countries on Factory Lighting.

The outstanding fact by which our Committee was faced was the absence of any general provisions in respect of lighting, analogous to those regarding temperature and ventilation, in the *Factory Acts of the United Kingdom*.

One of the most valuable sections of the Report is that in which a summary is made of the legislation bearing on industrial and school lighting in the chief European countries and in the United States of America. Many of these regulations were introduced a number of years ago; it will be seen that in most cases these are of a very general character, and in the light of the experience acquired during the last few years it is now possible to aim at greater precision in the definition of terms used (such as the meaning of adequate and suitable lighting). It need scarcely be said that the work carried out by the illuminating engineering movement since the formation of the Society has been of the greatest value in paving the way for this investigation. The facility with which measurements of illumination can be made has been much increased, the essentials of good lighting have been discussed in many aspects, and the ideas of authorities on debatable points in illumination have been greatly clarified. One other special result of this work has been the bringing about of a general recognition that illumination cannot be satisfactorily dealt with by

engineers alone, but that the co-operation of other experts, physiologists and architects, physicists and the general public is needed. This is now generally recognised. The French Government, in forming their Committee in 1911, took care to secure the services of these various experts. The Departmental Committee includes among its members physicists, physiologists and engineers, and in receiving evidence every effort was made to secure representative views from architects, managers of factories, employers and employees.

I venture to think that the result has been a unique publication of which this country has reason to be proud. It is no exaggeration to say that in no other country has there been any Government publication on industrial lighting which can compare in respect to completeness and the amount of work done. At the present time such an investigation is a necessary preliminary to legislation. In most other countries enactments on lighting have been the work of a Government official, sometimes acting on the advice of engineering experts, and in these circumstances it was naturally only possible to deal with the subject in the briefest and most general manner.

Distinction between Official Government Report and Treatises by Societies and Individuals.

I would next like to deal with a point on which there has been a little misapprehension, the special conditions which necessarily limit a Government Committee. The preparation of an Official Report, to be regarded as a preliminary to legal requirements, imposes a special responsibility on the members of a committee. Its conclusions carry a weight which the suggestions of individual experts or even societies do not; and it must, therefore, be particularly careful to avoid giving expression to views which are not thoroughly authenticated, and to explain its recommendations in the clearest possible terms. While the information given in the Appendices of the Report is chiefly of utility to people who are more or less experts on lighting, the body of the Report must be so drafted as to be intelligible to the general public and particularly to those who are concerned

with the legal aspects of it, but are not necessarily experts on illumination.

For this reason the terms used in the Report have been defined more fully than would, perhaps, be necessary for members of our Society, and it was frequently necessary, as a justification of the conclusions, to make statements which we, as a Society, may regard as truisms, but which those unfamiliar with matters of illumination would not.

This point may be illustrated by a comparison with two other valuable contributions to the study of industrial illumination, the "Code on Factory Lighting" issued by a Committee of the American Illuminating Engineering Society last September, and the booklet on "Industrial Lighting" issued by the National Electric Light Association in the United States in 1912.

The Code is a most useful publication. Properly regarded it confirms in almost every respect the recommendations of the Departmental Committee, but the fact of its not being an official Government publication enabled its compilers to put forward certain data (such as the illumination desirable for various classes of general work) which our Committee preferred to leave open for further and fuller investigation. As a publication sanctioned by the American Illuminating Engineering Society, however, the Code carries considerable weight and imposes on its compilers some responsibilities. It has, therefore, not attempted to enter into more debatable matters, such as a detailed survey of the conditions of illumination required in a large number of technical operations. The Code was prepared presumably for the guidance of those engaged in arranging the lighting of factories, and is illustrated by a few typical examples showing the advantages of good illumination.

The booklet on Industrial Lighting is again of a different character. It does not profess to apply to all systems of lighting, but only to illumination with electric lamps, and it was not issued by a Society, but by a commercial organisation. It was, therefore, practicable to give much more detailed instructions with regard to lighting for various industrial operations and to prescribe the actual lamps and type of reflectors used in each

case. The book is intended as a lighting specification, and its recommendations represent standard practice. It would, of course, be admitted that in many of these cases there is room for discussion and that, as new types of lamps and fittings are introduced, some of the recommendations would become obsolete. As a guide to industrial illumination it contains much useful information, but the suggestions are admittedly tentative, and at the present time it is clearly impracticable to introduce legislative requirements on such a detailed plan.

Chief Points of Interest in the Report.

From the standpoint of our Society it may be suggested that the chief points of interest in the Report are :—

(1) The recommendation that there should be statutory provision :—

(a) requiring adequate and suitable lighting in general terms in every part of a factory and workshop, and

(b) giving power to the Secretary of State to make orders defining adequate and suitable illumination for factories and workshops and for any parts thereof or processes carried on therein.

(2) The recognition of the value of good illumination as desirable in the interest of the safety and general health of workers, and as an important factor influencing the output and quality of work.

(3) The actual record of work done contained in the Appendices comprising data and measurements obtained in many factories, supplemented by the general impressions of the observers; and the summary of the requirements as regards lighting in the chief European countries and the United States.

As our knowledge regarding the requirements of good lighting increases, we find that recommendations become more precise and explicit. It is of interest to notice that the latest Indian Factory Act, 1911, makes a special reference to lighting as follows :—“(1) Every factory shall be sufficiently lighted; (2) In the case of any factory which is not in the opinion of the inspector so lighted, the inspector may serve on the manager of the factory an order in writing specifying the measures which he considers necessary for the

attainment of a sufficiently high standard of lighting, and requiring him to carry them out before a specified date."

It may be suggested that, with a view to avoiding misunderstandings, recommendations of this kind should preferably be supported by fuller instructions as to what constitutes good lighting. In the recently issued Report it should be particularly noted that "adequate and suitable lighting" is defined, not as involving only the provision of a certain amount of illumination, but also as implying satisfactory conditions in regard to the avoidance of glare, inconvenient shadows, &c. The recommendations of this Committee are unique in that they are the result not only of evidence tendered by a very varied set of witnesses, but of personal experience and a very exhaustive series of tests undertaken by the Committee. Some idea of the work entailed may be gathered from the data so far published but it should be remembered that there is still another volume to come, which will contain a detailed account of the lighting conditions in each factory visited, the measurements of illumination, and the personal impressions of the Committee thereon. These data should certainly be of considerable value as showing the actual conditions of illumination prevailing in the classes of factories visited.

Besides its manifest utility to the general public the Report should be much appreciated by the lighting industry since it provides a definite and official recognition of the importance of lighting, which should be of great value to all who are engaged in working for the improvement of industrial illumination. I venture to think that this broad view of the utility of the Report is one which should commend itself to the Society; and that in comparison the possible bearing of its conclusions on the applications of this or the other illuminant is of secondary importance.

With a view to ascertaining possible points for discussion I have taken some pains to examine the comments on the Report in various journals interested in lighting matters which have been brought before my notice. Some of these views are presented in tabular form. The list of journals is not in any sense complete, but from those so far examined it is

evident that the value of the Report is appreciated in a great variety of papers dealing respectively with engineering, hygienic and architectural matters. [This list includes, among others, the following:—*American Gaslight Journal*, *Architect*, *Electrician*, *Elec. Engineering*, *Elec. Industries*, *Elec. Review*, *Elec. Times*, *Engineer*, *Engineering*, *Gas World*, *Hardwareman*, *Illustrated Carpenter and Builder*, *Journal of Gaslighting*, *Lancet*, *Sanitary Record*, *Times Engineering Supplement*.] (See pp. 490—491.) I would like to draw attention to one enterprising step taken in the issue of the Report, namely, the publication of a four-page Memorandum, summarising the chief points of interest and giving the essence of the material contained therein. An abstract of this kind is a great aid to journalists when reviewing a bulky Government Blue Book, and it is also desirable in the interest of the Department by whom the Report is issued as it ensures that the chief objects of the publications are not lost sight of in a mass of detail. It is interesting to see that most of the journals that have commented on the Report have made use of this Memorandum. I believe that the issue of an explanatory Memorandum is a new precedent in connection with Government publications, and I venture to suggest that it might be followed as a matter of routine by other Departments in the future, as it supplies a much-needed bridge between highly technical but valuable official information and the general public.

Anyone reading the Report must be struck by the special pains taken by the Committee to render its contents easily understood, and to make it clear that its provisions are presented as a service to the public, and not in any sense as a hardship to manufacturers. I think that a perusal of the evidence will also show that the Committee have been most anxious to hear the views of all those interested in various aspects of illumination, and that they have lent a willing ear to suggestions. Doubtless the Committee would be only too glad to hear suggestions as to further work which would be beneficial, and it may be hoped that this friendly discussion will lead to fruitful results in this respect.

Some Points for Discussion.

The reception of the Report in the Press has been, almost without exception, friendly, and in the one case in which its contents have clearly been misinterpreted and under-valued, it is not difficult to trace the motives of the writer.

In dealing with some of the comments that have been made, therefore, I do so merely in order to clear up a few evident misunderstandings.

(1) In a few cases it has been suggested that the Report contains a needless amount of explanatory matter and even truisms in regard to illumination. On this point something has already been said. It has been pointed out that explanations which appear needless to a lighting engineer may be highly necessary to the general public, for example, to backward manufacturers who have not thought much about lighting matters. Moreover, if a statutory requirement of adequate and suitable illumination is made and penalties are eventually imposed, the precise definition of "adequate and suitable" illumination becomes an important matter; the contents of the Report will form the leading guide as to what is meant by this term, and must therefore be framed to meet all such contingencies. Moreover, factory inspectors have not previously been entitled to take general action in regard to defective lighting, and they will have to proceed cautiously and to gain their own experience; for their guidance full and explicit information, even on apparently elementary points, will be very helpful.

(2) A few writers, particularly those who are accustomed to deal with lighting matters, and have therefore some knowledge of the order of illumination met with in modern up-to-date factories, have been disposed to think that the minimum values suggested are too low; or to question the principles on which they are arrived at. I need scarcely say that these values were not put forward without long and careful consideration. The aim of the Report is to avoid at all costs, recommendations which might subsequently be found to be too burdensome, and to involve unnecessary hardship to manufacturers. When taking an entirely new departure this is always a sound principle to work upon. One has

to strike a balance between what is desirable theoretically and what is practicable. The researches of physiologists have shown that in general a marked diminution of acuteness of vision begins when the range of illumination is reduced below the range of values specified in the Report; yet one's impressions in this respect depend very much on the state of adaptation of the eye and the success with which glaring points of light are avoided. In any case such estimates have to be considered with respect to the conditions actually found in practice. It is not enough to specify what is theoretically desirable, one must make sure that what one desires can be actually carried out. The estimate was therefore checked by a very laborious series of measurements in many factories and the "frequency of occurrence" curves presented in the Report gave a clear guide as to the values which might be expected without hardship in factories at the present time. I may say that the minimum value prescribed in factories—0.25 foot-candles—has been independently arrived at in other investigations. It is, for example, the minimum value found on the platforms of railway station platforms* (where the safety and general convenience of passengers is the chief consideration determining the illumination), and it was independently suggested years ago as a result of investigations in the United States.†

It must also be recognised that these values are not average but "practical legal minimum" values. I notice that this distinction is emphasised in the American Code on lighting. The *minimum* foot-candle intensity is fixed (quite independently) at 0.25 foot-candles for storage, passages, stairways and the like, but the *desirable* foot-candle is placed somewhat higher, namely, 0.25—0.5 foot-candles; the latter value is not far from the actual minima met with in our investigations and recorded in the "frequency of occurrence" curves.

It need scarcely be said that with modern illuminants there is usually a

* See discussion before this Society, *Illum. Eng.*, Jan., 1912, pp. 26, 35.

† Resume of Legislative Enactments on Illumination, E. L. Elliott, Trans. Ill. Eng. Soc. (U.S.A.), Oct., 1911, p. 738.

TYPICAL COMMENTS ON THE REPORT IN TECHNICAL JOURNALS.

Journal.	Date.	Space (cols.) devoted to View expressed.	Comment.	Reproduction.	Remarks.
<i>Am. Gaslight Journal</i>	Oct. 25	2	Favourable		<i>Architect</i> .—Recommendations do not err on side of severity. Relation between illumination on working area and non-working areas (avoidance of excessive contrast) seems to have escaped notice.
<i>Architect</i> ..	Sept. 17	2½	Favourable		
<i>Electrician</i> ..	Sept. 20	three-quarters	Favourable	3	<i>Electrician</i> .—Committee have wisely contented themselves with general recommendations. Importance of material illuminated. 0.25 ft.-c. seems low, but minimum rather than standard practice. More attention should be devoted to glare. Report marks an advance which should be appreciated by all workers in factories.
<i>Elec. Eng.</i> ..	Sept. 16	1	—		<i>Elec. Industries</i> .—Appointment of Committee a proof of intelligent foresight. Enormous amount of munition work justifies recommendations on lighting.
<i>Elec. Industries</i> ..	Sept. 15	4	Favourable		
<i>Elec. Review</i> ..	Sept. 17	one-half	Favourable		<i>Elec. Review</i> .—Publication of results so far reached wise. Problem very complex. Recommendations only affect bad cases of factory lighting. Appendices of great value.
<i>Elec. Times</i> ..	Sept. 9	1½	Unfavourable		<i>Elec. Times</i> .—Objection is taken to the impartial tone of the Report in regard to illuminants and it appears to be implied that electric lighting should have been advocated.
<i>Engineer</i> ..	Sept. 10	1½	Favourable	1½	<i>Engineer</i> .—Importance of definition of "adequate and suitable." Actual measurement of illumination now as easy as measurement of temperature, but decision on minimum standard difficult. At present shop-lighting is provided on a generous scale because it is clearly recognised that parsimony in this matter is false economy indeed. But lighting arrangements are not planned with a photometer because no one can calculate beforehand how much light will be required and how much will be obtained by any suggested arrangement. By all means let the factory inspectors have power to demand adequate lighting. It is urgently required in not a few shops. But let the determination whether the lighting is adequate and suitable rest with the worker and the factory inspector's experience and general impressions, and not upon photometric measurements and legal minimum standards which cannot be made justly applicable to more than a few isolated sets of conditions.
<i>Engineering</i> ..	Sept. 10	2	Favourable		<i>Engineering</i> .—Report of service in view of large amount of munition work going on. An absolutely new departure. In respect to data collected the Report is admirable. Adequate lighting difficult to define but the Report makes no effort to evade the matter. Accident curves erratic, and, except in case of persons falling, doubtful.

Gas World.—Very valuable Report. Will be of great utility as a support to those trying to improve lighting in factories. Plain English, simple arithmetic, and lucid explanation, are good features. When one compares the pages of the Report in which technical terms are explained with text of similar import in the usual technical books and papers the difference is quite remarkable. Every gas supply officer should get its main conclusions by heart.

Writer expresses entire disagreement with *Elec. Times*.

Journal of Gaslighting.—Thorough and persistent work in an entirely new and difficult field. All agree as to importance of good factory illumination. Not much said as to ill-effect of bright light on the eyes. Doubtful if factory owner will dabble in measurements of parts of a foot-candle.

The time is distant when exact standards can be prescribed but if the work of the Committee produces improvement without absolute standardisation good will have been achieved. Definition of adequate lighting loose and uncertain. 0.25 ft.-candle too low and 0.05 in open spaces (*e.g.* in railway yards, etc.) absurd. In fine work local lights should be regulated to suit the eyesight of workers. Nat. Phys. Lab. experiments not applicable to factory conditions owing to absence of vibration, smoke, etc. Effect of colour of material shows that no general standard is practicable. Indirect lighting for most workroom operations unsatisfactory.

Report opportune as stating the case for good factory lighting, now that so much munition work is being done at night. (Gas undertakings, armed with the Report, can bring this point home.

(Other comments imply that the merits of gas lighting, in certain directions, have not, in the writer's opinion, been sufficiently emphasised.)

Lancet.—Everyone feels a difference in spirits if the day is dark and gloomy instead of bright and sunshiny, and this difference makes a measurable effect in terms of practical efficiency. Chief past obstacle the measurement of illumination now overcome. The fact that only 2–10 per cent. of natural light is admitted, even in best lighted factories, seems remarkable. Statements in regard to eyestrain confirm what is known or generally assumed to be true. Medical men will welcome the Report.

Sanitary Record.—To attempt to work in half or ill-lighted rooms involves intense strain on the eyes and affects the nervous system. At once the productive power of a person is impaired.

Times Eng. Supplement.—Report a confirmation of best official opinion rather than anything fresh. Statements regarding effect on output and the prevention of dirt useful. But Report needlessly filled with truisms, *e.g.*, (1) and (2) in definitions of adequate lighting and also advice in regard to daylight being preferable to artificial light.

<i>Gas World</i> ..	Sept. 11 Sept. 18	one-third three- quarters	5	— Favourable	<i>Gas World</i> .—Very valuable Report. Will be of great utility as a support to those trying to improve lighting in factories. Plain English, simple arithmetic, and lucid explanation, are good features. When one compares the pages of the Report in which technical terms are explained with text of similar import in the usual technical books and papers the difference is quite remarkable. Every gas supply officer should get its main conclusions by heart.
<i>Hardwareman</i> ..	Oct. 28	one-half	one-half	—	Writer expresses entire disagreement with <i>Elec. Times</i> .
<i>Illustrated Carpenter and Builder</i> ..	Oct. 29	1 1/4		—	
<i>Journal of Gaslighting</i>	Sept. 7 Sept. 14 Sept. 21 Sept. 28 Oct. 5 Oct. 12 Oct. 19 Oct. 26 Nov. 2	one-half 2 1/2	6 1/4 1 1/2 1 1/4 2 1/4 2 1/4 2 2 2 3	Mainly favourable but some criticisms.	<i>Journal of Gaslighting</i> .—Thorough and persistent work in an entirely new and difficult field. All agree as to importance of good factory illumination. Not much said as to ill-effect of bright light on the eyes. Doubtful if factory owner will dabble in measurements of parts of a foot-candle.
<i>Lancet</i> ..	Oct. 9	2		Favourable	The time is distant when exact standards can be prescribed but if the work of the Committee produces improvement without absolute standardisation good will have been achieved. Definition of adequate lighting loose and uncertain. 0.25 ft.-candle too low and 0.05 in open spaces (<i>e.g.</i> in railway yards, etc.) absurd. In fine work local lights should be regulated to suit the eyesight of workers. Nat. Phys. Lab. experiments not applicable to factory conditions owing to absence of vibration, smoke, etc. Effect of colour of material shows that no general standard is practicable. Indirect lighting for most workroom operations unsatisfactory.
<i>Sanitary Record</i> ..	Oct. 8	one-half		Favourable	Report opportune as stating the case for good factory lighting, now that so much munition work is being done at night. (Gas undertakings, armed with the Report, can bring this point home.
<i>Times Eng. Supplement</i>	Sept. 24			Favourable but some criticisms	(Other comments imply that the merits of gas lighting, in certain directions, have not, in the writer's opinion, been sufficiently emphasised.)

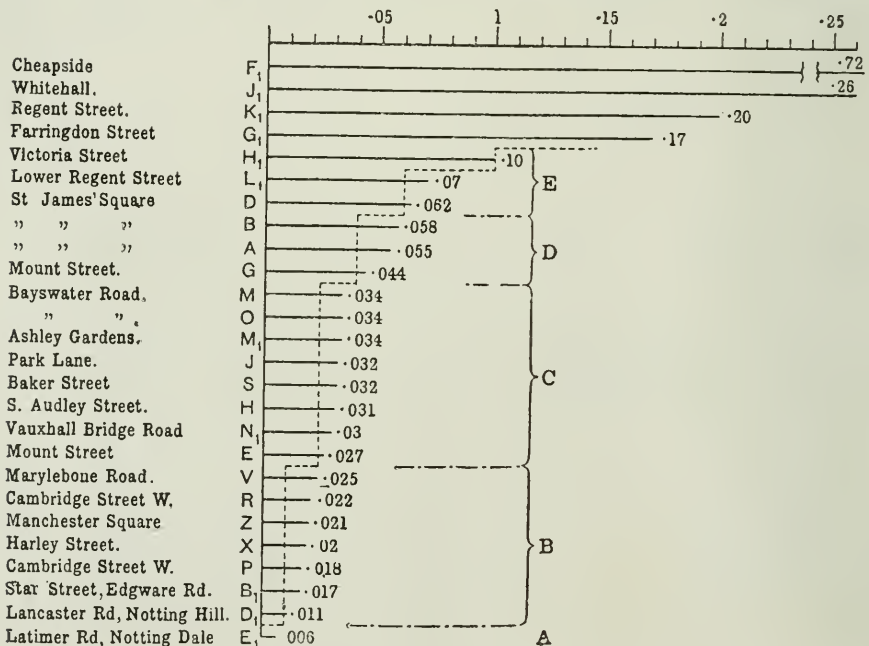
considerable variation in the illumination furnished at different points in the room, so that a minimum of 0.25 foot-candles at one point means that the illumination at most other parts of the room will be very much higher. Above all it must be clearly recognised that these are values in the interests of safety and convenience merely, and that in almost all cases the necessity of providing suitable illumination for the work carried on will in itself go far towards providing higher minimum values.

I think therefore that it will be conceded that the 0.25 foot-candle value has justification. But even so there will occur certain cases, particularly very large rooms and open spaces, where even this value could not be obtained without an unreasonably great expense. The Committee have therefore considered such open spaces separately and fixed lower minimum values, and have also inserted an exemption clause to meet hard cases. As regards the illumination in large open spaces, docks, &c., I think that few of those who have seen these large areas in practice will question the advisability of being very lenient in

fixing a minimum value. I notice that in one journal the suggested value of 0.05 foot-candles in such areas is spoken of as absurdly low. On the contrary I, personally, would have doubted the wisdom of asking even this value were there not the exemption clause as a safeguard. The conditions in such cases are utterly different from those encountered in an interior. There is no material gain of light by reflection from surroundings, and the lamps have to be spaced so far apart that the variation in illumination is necessarily very large. The best analogy is supplied by the full data available on the pre-war lighting of London's streets, so ably dealt with in Mr. Trotter's paper before this Society in 1913.* 0.05 foot-candles is about the value met with in St. James's Square, while in the Marylebone Road and in Cambridge Street there was only half this value. This is illustrated in the following diagram, taken from Mr. Trotter's paper :—

* Standard Clauses for Inclusion in a Specification on Street Lighting, by A. P. Trotter, *Illum. Eng.*, Vol. VI., 1913, pp. 250, 251.

Minimum Illumination in foot-candles received on a horizontal plane
3 ft. 3 in. from the ground.



In order to illustrate the great variations which occur in ordinary street lighting, it is of interest also to recall the following figures (from the same source) :—

Street.	Illumination on a horizontal plane 3 ft. 3 in. from the ground. Foot-candles.		Max./min.
	Min.	Max.	
St. James Square	-055		
"	-058		
(7.25 P.M.)	-062	1.86	32
Mount Street	-027		
"		0.86	24
S. Audley Street	-044		
Park Lane	-031		
(8 P.M.)	-032	0.60	19
Bayswater Road		2.28	
(9.45 P.M.)	-034		67
"		1.79	53
Cambridge Street	-034		
"	-018	0.63	31
"	-022		
Baker Street	-032		
"		1.24	
"		0.68	18
Marylebone Road	-025	0.60	24
Harley Street	-020		
"		0.37	18
Manchester Sq.	-021		
Lr. Berkeley Street		0.54	26
Star Street, Edgware Road	-017		
(11.40 P.M.)		0.83	49
Lancaster Road, Notting Hill	-011		
"		0.53	48
Latimer Road, Notting Dale	-006		

The well diffused illumination from a full moon in a clear sky, about 0.02 foot-candles, is regarded as a very useful degree of light for outside operations, so far as safety is concerned, so much so that in other countries where the climatic conditions are more regular street lamps have been dispensed with on moonlight nights. It may, of course, be said that in many industrial operations there are points where special danger is incurred, *e.g.*, where trucks are passing or where there are risks of

stumbling over obstacles and falling a dangerous height. But in such cases the general requirement of adequate lighting would come into force, and if there was obvious danger an inspector would be justified in recommending special measures at these points of work, such as the use of portable lamps, the whitening of surfaces to mark the demarcation from the dangerous zone, &c.

(3) A desire has been expressed that something more definite should be said on the subject of glare, and that a provision limiting the contrast between the illumination on the work and of surrounding parts of the workroom should be inserted. As regards the avoidance of glare I think the Report is sufficiently emphatic. At the present stage it is hardly practicable to include in the body of the Report hard and fast rules for its avoidance, as these necessarily differ so much according to the nature of the workshop: such precautions should, however, be studied by inspectors and applied by them in giving advice as to how a tendency to glare might be remedied.

As regards the avoidance of excessive contrasts in illumination this is met by two requirements. *Firstly*, by the general requirement that there should be a reasonable constancy of illumination over the working area; *secondly*, by the fact that the minimum general illumination is 0.25 foot-candles. According to Weber there is no impression of glare provided a contrast exceeding 100:1 in brightness is avoided; and even this ratio would perhaps be difficult to adhere to in practice. However, a ratio of 100:1, with a minimum illumination of 0.25 foot-candles, would permit of an illumination of 25 foot-candles on the work, which is only required in very exceptional cases.

(4) A few critics of the Report have suggested that some more definite information should be given under the heading "how to light a factory"; in other words that some form of specification should be prepared stating the amount of illumination for various processes and the desirable arrangement of lamps, &c.

It is explained in the Report that the specification of the illumination for the purpose of carrying out work has not

yet been sufficiently studied to justify us in putting forward definite values. Those who speak light-heartedly of brief and "practicable general schemes" of factory lighting can scarcely have studied the subject in any detail, and can have no idea of the innumerable complex factors affecting the conditions of illumination in various industries. Ideas on this subject can only become crystallised by gradual experiment and discussion in co-operation with those engaged in the respective industries, and it would certainly be foolhardy at the present moment to attempt to make such values a basis of legal action.

On the other hand those who accept the principle of the general recommendations in the Report and supplement this by a study of the data in specific factories presented, are already in a position to make substantial improvements in the more backward factories in regard to lighting, and this is surely a great point gained. Moreover, the introduction of new methods of lighting and improved illuminants keeps the subject in a constant state of flux and the values considered ample a few years ago are no longer accepted to-day. As an illustration I may mention that Holland, which a few years ago drafted a series of requirements for the lighting in certain industries, has recently found it necessary to double the original values.

I mention these facts to give an idea of the difficulty of including requirements of this kind in official recommendations on factory lighting. At the same time there is every reason to advocate unofficial investigations by experts on various problems in factory lighting, and our Society can, and I hope will, continue to add to the good work it has already done in this respect. The leading manufacturers of lighting appliances, too, are already doing excellent service in standardising requirements for their particular lighting appliances. The issue by the National Electric Light Association of the booklet on "Industrial Lighting" has already been quoted as an excellent piece of work of this kind.

(5) I notice in one article on the Report the following passage:—

"At present shop-lighting is dictated on a generous scale in every up-to-date

factory, because it is clearly recognised that parsimony in this matter is false economy indeed. The lighting arrangements are not planned with the aid of a photometer because no one can calculate beforehand how much light will be required and how much will be obtained by any suggested arrangement."

I have indicated above the complexity of the problems determining the illumination needed for various processes, but I venture to think the above statement exaggerates the difficulties. While it is doubtless true that experience, aided by measurements of illumination to serve as a record, is needed to fix the conditions of illumination required, there is no doubt that one can form a very fair idea of what is necessary, and in some trades the requirements are already becoming fixed within practical limits. It is also a fact that the systems of lighting recommended by up-to-date firms concerned with lighting are based on photometric measurements; there is no serious difficulty in determining beforehand, quite closely enough for practical purposes, the order of illumination which will result from lamps of a certain candle-power, equipped with standard forms of reflectors and located in predetermined positions. The evidence of several witnesses quite bore out this view.

(6) The statement that daylight is in general preferable to artificial light, and the advice to make the best use of daylight illumination on this account, have been regarded as a truism. If so, this is a truism that those responsible for planning admission of daylight would do well to bear in mind, for insufficient window-space is a not infrequent fault, especially in old-fashioned factories. The matter has also a special bearing on basements, and it is an arguable question whether insufficient daylight should be supplemented by artificial light, or whether daylight should be completely excluded before artificial light is used. The transition from daylight to artificial light needs careful handling and there is ground for thinking that accidents are particularly liable to happen at this period of the day. It has even been suggested that for reasons of health, basements which require constant artificial light should not be used as factories and workshops.

However, the whole question of daylight illumination is a most complex one, and would require in itself a separate evening's discussion. I must content myself on this occasion with pointing out the exhaustive data on this subject contained in the Report, which should be most useful to architects and engineers concerned with the construction of factory buildings.

(7) Finally, I may mention a few criticisms based on the impression that the merits of one or another illuminant have not been sufficiently emphasised. As I have indicated above, I regard these disputed points as of secondary importance in comparison with the aim of studying factory lighting as a whole and bringing about an improvement in the manner in which the illuminants are used.

Broadly regarded, these criticisms cancel one another, in one case the objection being raised that some advantage of electric lighting has not been pressed, in another the wish expressed that some merit of gas lighting had been more emphasised. I venture to think that keen partisans of particular illuminants do not sufficiently realise how greatly these presumed advantages depend on the local circumstances, and how frequently some apparent drawback is due not to any intrinsic defect in the illuminant so much as the unsatisfactory manner in which the illuminant is used. Members of the Society will agree that it is far better to aim at constructive work of value to the public and the industry as a whole, than to embark on controversial side-issues which merely accentuate points of difference.

Suggestions for Future Work.

There is room for detailed and systematic study of the requirements in regard to lighting in specific industries and no doubt this important piece of work will be undertaken in course of time. It is, however, work that obviously requires very careful treatment and one cannot expect immediate results. In view of the large number of factories working overtime on Government contracts the present moment was considered opportune for the issue of a Preliminary Report summarising the work so far undertaken and this, in itself, is surely a creditable result of two years' work.

There have naturally been some points on which evidence was less easily gathered than others and I would like to refer to several particular lines of investigation which would be helpful. One of these is the effect of inadequate illumination in causing eye-strain or general fatigue. While there is a very general recognition that inadequate lighting is detrimental to the health of workers, it is at present difficult to get sufficient evidence of actual cases, merely because no complete investigation of the matter has yet been undertaken. It is obviously a matter in which the co-operation of the physiologist and the oculist is necessary and in future we ought to study out some way in which the records of eyesight, nervous breakdown, &c., recorded by such specialists can be correlated with the lighting conditions which the sufferer has been experiencing. Only by slow systematic work of this kind can we hope to gradually trace the connection.

The physical condition of workers is of great importance at the present moment and a Departmental Committee under the auspices of the Home Office and the Minister of Munitions has recently been appointed to deal with the subject. An opportunity of bringing before their notice the relation between inadequate lighting and fatigue was recently afforded and no doubt they will consider the work of the Departmental Committee in the course of their researches and in framing their recommendations.

There seems at present to be a need for some general method of testing fatigue of eyesight. Experiments in this direction have been undertaken in the United States, but it is obvious that in studying different systems of illumination the variety of test imposed must be very carefully considered. Perhaps some of our members who are physiologists may be able to furnish some suggestions on this matter. One point seems to me clear; namely, that any such tests should take into account the time-element, *i.e.*, should be applied not at irregular intervals, but over a continuous period so that any fatiguing effect characteristic of the lighting system has time to make itself felt.

Another line of investigations which perhaps offers even greater immediate prospects, is the study of the connection between illumination and output and quality of work. One constantly hears of incidents illustrating the close relation between illumination and work accomplished, and several of the witnesses were able to mention actual instances of a measured gain in output and quality being observed when the conditions of illumination were improved. It is, however, difficult, particularly in the present circumstances, to induce manufacturers to consent to experiments on this point. It would be most useful if those of our members who are constantly dealing with industrial lighting installations were to begin to make a study of this matter and to collect as much evidence as possible on this economic aspect of good illumination. Certainly, in the future, it would prove one of the most powerful appeals to manufacturers if such statistics could be collected.

Some of you have doubtless heard of the wonderful results accomplished in the United States by the late Frederick Winslow Taylor, how by patient study of details, by watching industrial operations day by day, he was able to correct little deficiencies and to economise labour until the output in a given time was actually doubled or trebled. I have often thought that a similar method of watching and timing industrial operations could be usefully applied to lighting problems. Something of the same kind was undertaken by Mr. Thurston Kent in the United States some time ago. It need scarcely be said that in such work, as in experiments on fatigue, it is very important to secure comparable conditions when two systems of lighting are compared. The workers throughout must be engaged on precisely similar operations and of equal skill.

All these are lines of investigation which might very well be taken up now that the Report has brought before the public mind the value of good illumination. If it only served to pave the way for such experiments the Report would prove a

most useful piece of work, but I think that, in itself, it already furnishes much useful information to lighting engineers. This, indeed, is one piece of work in which this country may be said to have taken the initiative and to have been in advance of the rest of Europe. The same might truly be said of the Illuminating Engineering Society. The present war has brought home to us many remarkable features of German organisation and enterprise. It is of interest to point out that in this respect we took the lead and that, when some years ago, a society with similar aims to our own was formed in that country, the Reichsanstalt applied to us and obtained all the necessary information and guidance as to the method of conducting the illuminating engineering movement in England.

The great feature of our work, the opportunities it affords for common action between various experts and representatives of different systems of lighting, has surely proved its value to the lighting industry during the last six years, and I am sure we all recognise the importance of sinking any little rivalries and differences of interest that may exist and working shoulder to shoulder for the common good. Light is a necessity and not a luxury, and even in time of war it is necessary—perhaps even more necessary than in time of peace—to ensure that it is wisely employed. England has for long been justly regarded as the home of industrial hygiene, and our Society owes a debt of gratitude to the Home Office for the judicious and energetic manner in which they have taken industrial illumination under their wing. I think that I express the views of the members of the Society in emphasising the great services which H.M. Chief Inspector, Sir Arthur Whitelegge, has rendered to the study of the hygienic aspects of industrial lighting, and the importance which he has attached to good illumination, in several Annual Reports. Special thanks are also due to the Chairman of the Committee who has devoted so much time and care to these researches.

DISCUSSION.

Dr. R. T. GLAZEBROOK (chairman) said that the position was perhaps rather a novel one. The report which was to be discussed was the first report of the Committee, which was still in the middle of its work. There was a great deal to do, but by this time a great deal more would have been done had it not been for the position created by the war. The work carried out by the Committee had been of very great interest in very many ways, and the object of the discussion that evening was to gain information from the members of the Society which would be beneficial to the Committee in its future work. An inquiry of this kind which endeavoured to inquire into the conditions most favourable for work, and the conditions disadvantageous for work, and the laying down in general terms of the requirements for good work so far as illumination and eyesight were concerned, was one which must be fraught with great value in the future.

Dr. RENE SAND (*late Assistant Professor of Pathology in Brussels*) expressed his thanks for the kind reception given him by the Society. He had followed the work of the Society in this connection with great interest since the Brussels Congress, in which Mr. Gaster and Dr. Legge, of the Home Office, took such a prominent position. He had observed with great pleasure the resolution of the Belgian Academy of Medicine, urging the Belgian Government to take some steps on this question of factory and workshop lighting. He hoped, after the war, the Belgian Government would start to work energetically on this question and would find valuable data in the work already accomplished by this Society.

Dr. J. KERR said it seemed to him that the further work which must develop out of the Committee's report would be questions of fatigue and eyesight. The question of glare was extremely important, because it was not merely the illumination that affected

the individual, but also the individual who had to re-act to the illumination. A good many years ago he had to do with printers who were working on the new linotype machines, who complained that they could not do the work because they could not see the line of letters on the little block of metal, owing to it being so shiny. Inquiries showed that these men were smokers, and that they had a slight degree of tobacco amblyopia. By leaving off tobacco, however, it was possible for these men to get to their work again without disturbance from haze and glare. This question of the condition of the individual was an important one, and the production of after images, as Mr. Gaster had pointed out, was also to be considered in the case of combined daylight and artificial lighting. The report also dealt with the intrinsic brightness of the source of light, another thing of great importance from the after image point of view. These were the points which had appealed to him in reading through the report.

Mr. W. R. COOPER said he was glad the Committee had taken up the point of view of the comfort of the workers, which was a very important matter. Recently he had been looking at the new car inspection sheds of the London and South Western Railway Company at Wimbledon, and was interested to see that these open sheds were all heated so as to have things as comfortable as possible during the winter. There was no question that the best work could only be obtained under reasonably comfortable conditions. If the idea of consideration for the workers had been grasped by employers many years ago, much trouble would have been saved.

A point to be emphasised was the money value of good illumination, and if the Committee could get more instances of that, it would be an advantage to publish them. He could not help thinking that 0.25 ft.-candle as a minimum for work-room illumination was a bit low, and if the Committee could see their way to raise it, it would be an advantage. Perhaps this was going a little too fast and must be postponed for the future.

In any case it seemed to him that the term "workroom" was too vague at the present moment. Surely there must be great variations between one room and another, and he thought this question might have been taken up a little sooner than waiting for a further report. A workroom containing machines in an engineering factory must differ very materially from a workroom containing looms in a textile factory, more particularly for different materials under manufacture.

He did not know whether any reference had been made in the report to the exposure of the eyes to the source of light. If it could be done it would be a great advantage to call attention to the undesirability of exposing metal filaments to the eyes, *i.e.*, by using clear glass bulbs. Many people did this without hesitation, and the risk from it would become still greater when the half-watt lamp came into greater use. He thoroughly agreed with Mr. Gaster as to mixed light. A mixture of artificial light and daylight must always be exceedingly trying for the sight, and light of that sort should be avoided at all costs. Either have daylight altogether or artificial light altogether. He regarded the work that had been done as most valuable and the report itself as a step in the right direction.

Mr. A. CUNNINGTON (London and South Western Railway), as a practical worker in illumination, welcomed the results published by the Committee. The frequency of occurrence curves, summarising the readings of illumination in various factories, were especially interesting and altogether a new departure. It would appear from the report that the Committee in arriving at their conclusions made more use of actual measurements than of the expressed opinions of the witnesses, and undoubtedly this was the right course, for general impressions—even of people accustomed to dealing with lighting problems—were sometimes rather vague.

One or two figures suggested by witnesses in the minutes of evidence seemed wide of the mark. For example, one of the witnesses had suggested 2 ft.-candles as the *minimum* for corridor lighting. Directly one came to work this out one saw it was impracticable. He had pre-

pared a diagram (Fig. 1) showing corridor lamps 8 ft. above the floor and 17.3 ft. apart. In order to get a minimum illumination of 2 ft.-candles at 3 ft. above the floor it would be necessary to have lamps giving 200 c.p. at 30° below horizontal,

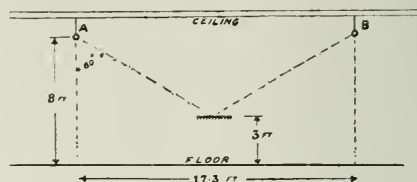


FIG. 1.—Lighting of corridors and passages.

whereas an ordinary corridor was of course lighted with 30 or 50 c.p. lamps, and sometimes only 8 or 16 c.p. A few actual values would still further emphasise the fact that 2 ft.-candles was far too high a minimum. He had been taking one or two readings in the new offices at Waterloo, where the corridors, which were quite comfortably lighted, gave a minimum of 0.1 ft.-candle and a maximum of 0.4 ft.-candle. The diversity here was very small and that probably accounted for the good lighting. In the corridor leading to the offices of the Illuminating Engineering Society, the minimum was 0.13 ft.-candle, and he thought everyone would agree that this was an excellently lighted place. The corridor outside the Institution of Gas Engineers gave a rather lower figures, being 0.075 ft.-candles, but that was due to the fact that alternate lamps had been removed owing to the present lighting restrictions. If it were assumed to be twice as much in normal times the figure would be 0.15 ft.-candle, still a very long way from 2 ft.-candles. In the Society of Arts building, on the stairs the minimum was 0.5 ft.-candle, but this was obviously exceptionally bright. The interesting point about all these tests was that they formed a striking vindication of the figure of 0.1 ft.-candle recommended by the Committee as a minimum for passage lighting. They must not forget that light of this character could easily be too extravagant, notwithstanding the argument (put forward by one of the witnesses) that as light was provided so cheaply there should be

plenty of it. Plenty of it, certainly, but not *too much*. An advocate of a certain system of lighting had once offered to give him five times the amount of light for the same amount of money as he was then paying, but he naturally retorted that he would rather have the amount of light he wanted for one-fifth of the price.

With regard to the lighting of open yards, he thought that the value of 0.05 erred on the side of being too high. In the case of a railway goods yard of about 11 acres, with the lighting of which he was concerned, the increase from the present actual minimum of 0.01 ft.-candle to 0.05 ft.-candle would involve an increase in expenditure for current alone from £300 to £1,500 per annum, assuming the existing installation was made use of. The increase would doubtless be less if the lamps were placed closer, but he estimated that under the best possible conditions the cost would be doubled in order to secure a minimum of 0.05 ft.-candle.

An editorial note in the *Journal of Gas Lighting* had ridiculed the figure recommended by the Committee, but in the hope of convincing the writer of this note that the Committee were well on the safe side he had, when recently visiting the offices of the *Journal*, taken a reading on the floor of the publishing department. He did not know whether this would be considered a "working area," a "passage," or an "open yard," but he could assure them that the illumination actually fell below the lowest minimum recommended by the Committee—it was in fact 0.035 ft.-candle. He need hardly say that this floor was not in the least dangerous to walk about on, nor was the lighting of the office as a whole in any way deficient. He merely mentioned this instance to show what a low degree of illumination we were accustomed to consider safe. Furthermore, he wished to emphasise that it was *minimum* illumination, *i.e.*, the darkest corner, that was specified, and this must not be confused with *average* illumination. Incidentally, if an instrument could be devised which would show the value of illumination in the same way as a thermometer indicated temperature it would be a valuable thing, and possibly the Society might award a gold medal to the inventor!

It had occurred to him that in view of the possibility of a minimum illumination becoming statutory, it might be of value to be able to predetermine the cost of lighting a yard with a given minimum. This could easily be done provided the average illumination which corresponded to the stated minimum could be arrived at. Then it would only be necessary to multiply the area of the yard by the average illumination to get the number of lumens required, and from the known efficiencies of various illuminants these lumens could be converted into actual cost. The difficulty was to arrive at the average illumination, but he thought the following method would give a reasonable approximation. A knowledge of the diversity ratio for a given system of lighting would enable the maximum to be deduced at once from the minimum. This diversity ratio would depend on the spacing of lamps, and could in most cases be estimated pretty accurately. It was clear that the average illumination would not lie half-way between the maximum and the minimum, because of the rapid falling off in the distribution of light from a source. He showed two typical horizontal distribution curves (Fig. 2) in which he had

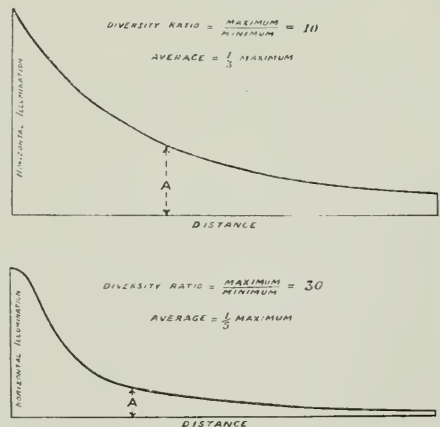


FIG. 2.

calculated the average by dividing the area of the curve by its base. In one case the average was one-third of the maximum, and in the other case, where the falling-off was more rapid, the average was only one-fifth of the maximum. In this way, by plotting the horizontal distribution

curve of the particular lamp between the maximum and minimum values as given by the diversity ratio, it was possible to get at a working average illumination, and thus to predetermine the cost.

He would like finally to refer to the question of accidents on railways. He had had access to the Board of Trade returns, and had thought it would be interesting to analyse them out and plot them in diagram form (Fig. 3). He had

gers an increase in the third quarter of the year was explained by the fact that it included the holiday traffic.

He did not know if it was generally realised that at a Board of Trade Inquiry into an accident, some of the first questions usually asked were in reference to the lighting—whether the lights were all on, were they in good condition, when were they last cleaned, and so on. It was clear that the Board of Trade Inspectors

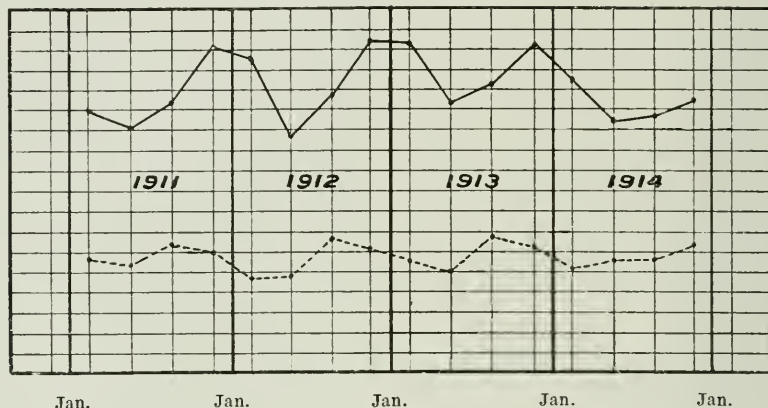


FIG. 3.—Showing relation between accidents and the period of year on railways (taken from Board of Trade Returns). Upper curve refers to railway servants, lower curve to passengers. (Accidents on the permanent way and in trains and rolling stock are omitted as being unaffected by lighting conditions.)

taken the accidents which were more or less dependent upon illumination, *i.e.* he had eliminated accidents occurring to trains, permanent way, or rolling stock. The upper curve showed the accidents to railway servants and the lower curve those happening to passengers. In the case of railway servants, the figures showed that these were very much more general in the winter quarters than in the summer. The somewhat smaller increase in the fourth quarter of 1914 might presumably be due to the fact of the reduction in the number of railway employees by enlistment; but taking the figures over a period of years, it seemed that there were 18 per cent. more accidents during the winter than the summer. After making due allowance for fogs, &c., he thought it could be safely deduced that the greater frequency of accidents in the winter was mainly due to the dark days. In the case of passen-

regarded adequate illumination as an extremely important matter.

Mr. C. C. PATERSON, having congratulated the opener of the discussion, expressed his interest in Mr. Cunningham's accident curves, which, if anything, under-emphasised the effect studied as to the extent to which accidents occurred during the winter months. Winter months, of course, contain a lot of daylight as well as artificial light, and the daylight accidents would be presumably the same as the daylight accidents in the summer months, so that an increase of accidents in the winter months was purely the result of additional accidents during the few additional dark hours in winter over the number in summer. If we were to try to work out these curves on the basis of the actual hourly rate at which the accidents occurred during the hours of evening as compared

with the hours of daylight, the curves would be still more exaggerated. This was a point to be taken into consideration in connection with comparisons between accidents in the winter and summer.

He would recommend those who desired to judge of the general condition of lighting in this country, to study the volume of the report which was about to be issued and which contained much statistical and other information and detailed plans of factory premises.

Mr. JUSTUS ECK said it was not often that a branch of engineering was so thoroughly taken up and dealt with by the Government as had been done in this case, and he hoped that it would not be long before the third volume of the report of the Committee appeared. If there was any prospect of this being delayed, perhaps some means could be taken to publish an interim report covering the scope of the new volume. The urgency of the matter was very great at the present time, as so many of our factories were working all hours of the day and night, and which brought them within the category of the railways, in which there was no cessation of work during the whole of the 24 hours.

One of the most important things to consider in factory lighting was the effect upon the eyesight, and in this connection it was very sad to see the large number of people who wore spectacles, the use of which in many cases from his own observation was a considerable hindrance to the working facilities of the man. Anything which could be done to render the necessity for spectacles less, would be a service not only to this country but to the whole world. The general tendency was to continue to hurry on improvements in our producing methods and to overlook the effect of good lighting upon the eyesight of the workman who would work on these improvements in producing methods, often causing an expense in other directions.

He would also like to see some method devised for compelling greater attention to reports such as this. Recently he had had to visit a number of small factories, and had been surprised at the almost universally bad lighting systems. At a small works in Canning Town on the previous day where it had been necessary

to put up blinds to comply with the present lighting restrictions, dark green blinds had been used, and the result was worse, internally, than before. He immediately suggested the very simple remedy of pinning a few newspapers over these blinds, and putting a little white-wash on the walls, with the result that he was certain the factory output had been increased by five, if not ten, per cent., and there was certainly greater safety. In another factory, he had all the blinds faced inside with white material, and the output was better than ever before. To emphasise this point, he might mention that he had visited a good many factories in the United States, and although the Illuminating Engineering Society of America had been longer at work than our Society in this country, it did not seem to have brought home to manufacturers so clearly as we had, the necessity for better lighting in factories. He had been deeply disappointed with factory lighting in general in America. Another point which the Committee might take into consideration in its further work was the question of the colour of light. He had had to advise in connection with the lighting of some works where small objects were being produced in large quantities in brass, and there had been great difficulty in the supervision and inspection of these owing to the colour of the artificial light.

Mr. LEWIS SOLOMON, speaking from the architect's standpoint, said that he preferred to work by rule of thumb. In designing a factory, he asked the manufacturer where he wanted the light and followed his instructions both as to artificial lighting, and natural light in the matter of windows. It had occurred to him, however, that if factory inspectors could be instructed to report to some authority the superficial and cubical amount of light, whether vertical, horizontal, or at an angle in each factory they visited during the year, *and to report also whether the result was good or bad* (this information being obtained from the manager of the works) a considerable amount of valuable data would be accumulated.

Mr. E. F. SWINSON agreed with Dr. Kerr in attaching considerable importance to the question of fatigue from bad lighting and in this connection also matters relating to ventilation and heating must come under consideration. It was easy to put down a certain indicated result as being due to a particular cause, but in practically every instance there would be conjunctive factors present, and to give predominance to lighting was to leave out of consideration important questions relating to fatigue, ventilation, and heating.

Mr. G. CAMPBELL said he was sorry to have to strike a note of discontent with the Report, because he fully appreciated the immense amount of labour involved in compiling such a record. In spite, however, of Mr. Gaster's able defence of the Report, he was still of the opinion that apart from its collection of miscellaneous information it must, from the point of view of its recommendations on the numerical values for suggested standards of illumination, be regarded as a disappointment. Irrespective of the explanation, anyone who had any practical experience must know that an illumination of 0.25 ft.-candle for factory lighting was totally inadequate for 99 per cent. of examples.

He presumed that the intention of the Committee was to obtain legislation that would compel all factory proprietors to adopt necessary lighting.

In his opinion the Committee had missed a great opportunity in not coming out with a flat declaration that the minimum result for good illumination in workshops is generally 1 to 3 ft.-candles, and that otherwise the lighting of factories would be bad.

Added (communicated): It is hardly necessary for me to add that my remarks as to foot-candle values applies to workshop-interior lighting and not to exterior lighting, where special circumstances other than foot-candle values must be considered, with regard to which anyone interested can refer to the discussion on and the Report of the Society's Street Lighting Committee.

Since the meeting my attention has been drawn to the point that the value of

0.25 ft.-candle is intended as a practical *legal minimum* in the interests of *safety* only, and is quite apart from the much higher illumination necessary for the carrying on of work which would come in the Report under the heading of "adequate and suitable lighting." For such purposes, I hope, standards will be eventually prescribed by the Committee. These values would necessarily be much higher. In the meantime the 0.25 ft.-candle minimum recommendation must not be confused with satisfactory workshop-interior illumination.

It is in the sense, then, of indefinite recommendations as regards "adequate and suitable lighting" that I consider the Committee's Report disappointing, but in no way wish to detract from the value of such Report from the standpoint of the progress of the Illuminating Engineering movement.

Mr. F. W. GOODENOUGH differed from the last speaker in regarding the report as "a disappointment." On the contrary, he regarded it as a very great achievement to have established the principle that adequate and suitable lighting for factories and workshops should be a statutory requirement. It was very necessary in these matters to build sound foundations before putting up a big super-structure, and the Committee had done wisely in making a small beginning with regard to the minimum. At the same time they had made a very large beginning in establishing the principle that the good lighting of a factory was one of the conditions which enabled it to be passed as satisfactory by the Home Office inspector. It was a very important principle in legislation not to go too far in advance of public opinion; otherwise there was a risk of the legislation being brought into contempt and thrown into disuse. It was the work of the Society to advance public opinion in this question of satisfactory illumination, as to the minimum, maximum and average illumination, and if public opinion was educated in this respect, it would be easy to get legislation to follow. Legislation must always be subsequent to the education of the public, or it would fail of its object. The great problem of the nation not only at present, but in the years to

come, was how to increase the output of wealth in this country (*i.e.*, the output of labour) in order to provide the means to pay for the war, and if by the adoption of statutory requirements as to the lighting of factories, we could bring about a natural increase in the output per man, we should have done a service to our day and generation. In that respect he maintained that the report was a very valuable step in advance. With regard to Mr. Cunningham's remark as to the man who advocated a high degree of illumination because it could be obtained cheaply, personally he was not interested for the moment in what the illuminants might be, but Mr. Cunningham must bear in mind that it was only by the advent of cheap illuminants that we had been able to get the standard of lighting raised to anything like the present figure. It was the line of argument that the metallic filament lamp maker used against the carbon filament lamp maker, namely that he was able to give a better light because it was cheaper. Progress should be utilised partly in getting a better result, and partly in getting economy, and if we had not got beyond the tallow candle at the present day, it would not be possible to prescribe standards of illumination for factories. He thought that Mr. Cunningham would recognise that the witness who advocated 2 ft.-candles for passages was merely emphasising the real truth that before thorough efficiency was obtained there must be economy.

H. C. WHEAT (*communicated*):—Just as everyone connected with the lighting industry welcome the appointment of a Committee to inquire into Industrial Illumination, which was no doubt intensified when the names of the gentlemen forming the Committee were published, so the issue of the first report of the Committee, with its extensive appendices, should bring conviction to others of the importance of the subject, and its enormous extent. The due appreciation of all the work and time that the first report represents, must, to a large extent, be limited to those whose daily work renders them familiar, at any rate to some extent, with the different aspects of the subject. As one of the latter I should like to record myself.

From the various comments that have already appeared, it is evident that the Committee had no small task before them if they were to make definite proposals for all the different conditions which seem to be considered within their scope. One can well understand that in making recommendations for legislation it is easy to be carried away by an ideal, and to forget the hardships, and perhaps injustice, which such a proposal would enforce on those required to carry it into effect. This doubtless explains why the minimum values suggested appear so low to many of us who are accustomed to frequently make recommendations for similar cases on a much higher scale.

In eventually deciding on the conditions of illumination necessary for various classes of work, it might be well to consider the distinctions implied by:—

- (1) General illumination;
- (2) Localised general illumination;
- (3) Local lighting.

In such cases the minimum values would naturally be specified on the "working plane" rather than floor level.

One may also hope to see in course of time more detailed recommendation on the screening or shading of light sources, seeing the number of offences against this which are committed. Almost any works will afford an example of this, and also of the fact that protection is desired, judging by the number of lamps that are furnished with scraps of paper, or other amateur efforts at shading.

The appendix may appear antagonistic to inverted lighting, but should not be construed as applying to general conditions. In these experiments the majority of the tests recorded are made on self-colour fabrics, &c., where unidirectional light is most necessary for clear vision, and for which, therefore, indirect lighting is naturally unsuited; in fact, no unbiased person would suggest it for such duty. There are, however, admittedly other classes of work where the diffusion and other excellent properties of indirect lighting render it far superior, and the efficiency of the eye remains higher under this than in any other system of artificial lighting. No one could expect that a sudden change from direct to indirect lighting would favourably impress any

ordinary person. It is fairly well established that people largely estimate the value of light by what they can see of the light source, and even with direct lighting people *fancy* that there is more light when the source is exposed rather than when screened.

In conclusion, I am sure that we all are very much indebted to the Committee for the work they have done, and for a great deal of valuable information which they have given us.

The CHAIRMAN, before calling upon Mr. Gaster to reply, said the discussion had placed a considerable amount of information at the disposal of the Committee, and a good indication had been given as to the way the report was looked upon, and what were the points the members of the Society desired further investigated. To all of these the Committee would turn its attention when it was able to resume its work. The question raised by Dr. Kerr and Mr. Swinson with regard to the questions of fatigue and glare were clearly of the very utmost importance.

Mr. LEON GASTER (*in reply*): In the course of my introductory remarks I expressed appreciation of the sympathetic way in which the Report has been received in the press, and would like to express now my pleasure in listening to the cordial remarks of the various speakers in the discussion. It is gratifying to feel that the great importance of the Report, as a step forward towards better industrial lighting, is fully recognised by members. No doubt this beginning will be followed up by other useful work.

It was a great pleasure to see present Dr. Rene Sand, whose acquaintance I made at the important Brussels Congress, and to have his assurance that when happier times arrive, the question of industrial illumination will receive the attention of authorities in Belgium.

Dr. Kerr's remarks on the effect of poor illumination in causing industrial fatigue were most welcome. The case he mentions of the increased sensitiveness to glare caused by tobacco amblyopia illustrates one point mentioned in the introduction, namely, the close relation between defects of vision and the illumination required for work. Inadequate

illumination, it is generally agreed, imposes a strain on the eyes; similarly defects in vision, whether due to some physical disturbance or to general bodily fatigue, will often make a worker sensitive to defects in lighting which might otherwise pass unnoticed.

Mr. W. R. Cooper, while referring to the Report in sympathetic terms, made one or two suggestions, for example, that 0.25 foot-candles appeared somewhat low as a minimum. The reasons for selecting this value were somewhat fully summarised in the introduction, but I may add that one other reason for not making the value desirable in the interests of safety and convenience too high is that in this way the obvious need for a much higher value for the work is made evident. Had a higher value, say one foot-candle, been demanded there would naturally have been some confusion between this and the illumination necessary for carrying out processes, and there might have been a tendency to assume that the legal minimum was all that was needed. By adopting 0.25 foot-candles we ask for a value which is clearly justifiable, does not impose hardship, and yet makes it clear to the factory owner that additional illumination for the work must also be provided; or, on the other hand, if there is local lighting on the work the illumination of the rest of the area must reach the minimum desirable in the interests of safety.

Mr. Cooper also suggested that some attempt should be made to discriminate between different classes of workshops. All must agree that the requirements of workshops differ very much according to the nature of the work, and naturally this point would be sympathetically considered by inspectors of factories. On the other hand, when one comes to attempt a classification, one finds oneself in great complexities, and it therefore seems better to start with simple recommendations which can be applied to all. No doubt when one comes to consider the requirements for different classes of work some broad lines of classification will have to be considered.

Mr. Cunningham's very able contribution to the discussion fully confirmed, by actual observations in well-lighted passages, the view that a minimum

of 0.1 foot-candles is ample in such cases ; and that in respect to the lighting of large yards and sheds, 0.05 foot-candles could not be considered unduly low. Indeed, it is interesting to observe that in his experience it might, in some cases, be difficult to secure even this value with a reasonable expenditure. Hence the need for the exemption clause. Mr. Cunningham's figures for accidents on railways are also most interesting and show how careful one must be in interpreting statistics of this nature.

Mr. Eck expressed the hope that the Report would receive widespread attention. It should be the work of this Society to ensure that its contents are made known to all interested in lighting, particularly engineers concerned with lighting schemes. Illuminating engineers should study the Report in detail, and I venture to think that the Memorandum accompanying it will help considerably towards making its main points clear. Mr. Eck's instance of the effect of good illumination in increasing output was welcome, and we should like to get all the information we can of this kind. The question of the colour of the light is, as he says, a most important one in certain trades ; this, however, will no doubt be a subject for the Committee to consider at a later stage.

I quite agree with Mr. Swinson that ventilation and heating is a most important matter and must often be considered in conjunction with the lighting, especially in daylight work.

With reference to the point raised by Mr. Campbell, I am glad to note that since the meeting he has recognised that the 0.25 foot-candles is to be provided *without prejudice* to the illumination necessary for carrying on work. Naturally, in those cases where the factory owner provides a high general illumination all over the shop, there will be no difficulty in keeping above the prescribed minimum value, but it is also necessary to ensure that in those cases where local lighting over the work is used, the illumination in the intermediate regions will be sufficient for safety. As mentioned in my remarks on Mr. Cooper's contribution, the mere fact of this "safety-illumina-

tion" being comparatively low, and obviously insufficient for carrying out any but the roughest work, is the best safeguard against any confusion of the kind Mr. Campbell fears. If, however, one were to ask for *one* (or still more, *three*) foot-candles everywhere, there would be a risk of such confusion. For many processes even this illumination would not be enough, while in others it would constitute undue hardship. Mr. Campbell will find that Vol. III. of the Report will afford much information as to the actual conditions of illumination which prevail in factories at the present time.

Mr. Goodenough, out of his large experience, has expressed his appreciation of the Report and his recognition of the need for cautious procedure in dealing with novel problems in legislation such as this. The mere fact of such a Report being issued is surely a great vindication of the value of the illuminating engineering movement. Needless to say, we must also all agree with Mr. Goodenough that advances in illuminants, by cheapening light, have had a great and beneficial effect on illumination. As a Society we should certainly impress on the public the foolishness of parsimony in this respect.

Since the discussion a communication has been received from Mr. Wheat, who gave most useful evidence before the Commission. Mr. Wheat emphasises the need for good shading appliances, a point that was also raised by Mr. Cooper.

I think that it will be agreed that this point has been most strongly emphasised in the Report and it forms one of the four requirements under the general head of "adequate and suitable lighting," namely :-

- (1) Adequacy.
- (2) A reasonable degree of constancy and uniformity of illumination over the necessary area of work.
- (3) The placing or shading of lamps so that the light from them does not fall directly on the eyes of an operator when engaged on his work, or when looking horizontally across the workroom.
- (4) The placing of lights so as to avoid the casting of extraneous shadows on the work.

I quite agree with Mr. Wheat that the few tests on indirect lighting should not be interpreted as a general condemnation of this system, and only apply to the particular processes specified (embossed materials, engraving on metal, &c.), which appear to require special directional lighting. In the Report itself it is definitely stated that no differentiation has yet been made between direct and indirect lighting, and the experiments on this point were incomplete when war broke out. Nevertheless, it seemed desirable to include these experiments among the others in this section of the Appendix.

In conclusion, I would like to express the opinion that the claims of good illumination are so clear that I am confident that they will be accepted by

manufacturers with very little persuasion; any attempt to impose unduly severe requirements before they are fully understood or appreciated would in the long run be prejudicial to the cause of good lighting, and this is fully recognised in the moderate tone of the Report.

I should, however, like to say that I quite sympathise with the views of those who would like to see some more detailed treatment of problems in industrial lighting, in order to supplement the general official recommendations in the Report, and I hope that our Society will deal with these matters in future meetings. Finally, I must express my very great appreciation of the kindness of Dr. Glazebrook for presiding to-night in spite of the many calls on his time at the present moment.

NEW MEMBERS OF THE SOCIETY.

THE names of applicants for membership read out at the previous meeting on May 18th were formally announced at the last meeting on November 23rd, and these gentlemen were formally declared members of the Society.

In addition the names of the following gentlemen have been duly submitted to the Council and were read by the Hon. Secretary at the last meeting :—

Brown, Douglas Elyard	Electrical Engineer to Messrs. C. A. Vandervell & Co., Hillbank, Abbots Langley, HERTS.
Butts, E. W.	Messrs. Siemens Bros. Dynamo Works, Ltd., Upper Thames Street, E.C.
Ellis, F.	Manager of Messrs. Johnson & Jorgensen, Ltd., Glass Suppliers, Farringdon Street, LONDON, E.C.
Grigsby, O. E.	Electrical Engineer, The Benjamin Electric Co., Rosebery Avenue, E.C.
Pallot, A. C.	Lieut., Royal Engineers (T.F.), St. Heliers, Sheffield Road, PORTSMOUTH.
Wells, C. F.	Dundee Corporation Electricity Works, DUNDEE.
Wood, W. H.	Manager, Commercial Acetylene Co., 712, Dufferin Street, TORONTO.

AN EXAMPLE OF MODERN OFFICE LIGHTING.

OFFICE lighting, broadly speaking, includes a great variety of installations. The needs of a small office where there are only a few desks and typewriters to be lighted are essentially different from those of large banks, insurance offices, &c. In the latter case there are often a large number of people at work in a single room, and there are other considerations besides the purely utilitarian one for providing enough light for the work to be done. In buildings of this class an imposing interior, in keeping with the important character of the business transacted, is necessary. People entering a building of architectural distinction are favourably impressed by the substantial character of the firm, whereas they would be inclined to think less of a concern with badly arranged and poorly lighted offices.

In such cases, therefore, the lighting scheme should be dignified and imposing, in keeping with the character of the interior, and the decorative element comes into play. The lamps and fittings must not only accomplish their primary purpose of providing light at the desks and counters, but should "set off" the interior to the best advantage and enable its architectural features to be appreciated.

A good instance of modern office lighting is furnished by the new office of the Phoenix Assurance Company, Limited, in King William Street, London, E.C. This building, which is one of the finest in London, is from designs in the Classical Renaissance style by the late Mr. J. Macvicar Anderson and Mr. H. L. Anderson. The entire block covers an area of 12,000 square feet, and is eight storeys in height, thus affording ample scope for ingenuity and good taste in the matter of lighting. By the courtesy of the Consulting Engineer, Mr. S. G. Castle Russell, we were recently afforded an opportunity of taking a few photographs and measurements of the illumination in this building. The illustrations give a fair idea of the general design, although the proportions are rather too big to be conveniently

shown in a photograph. Readers will, no doubt, be struck by the rather singular grey columns. We understand that these columns will eventually be light marble—but the material is held up during the German occupation of Mons.

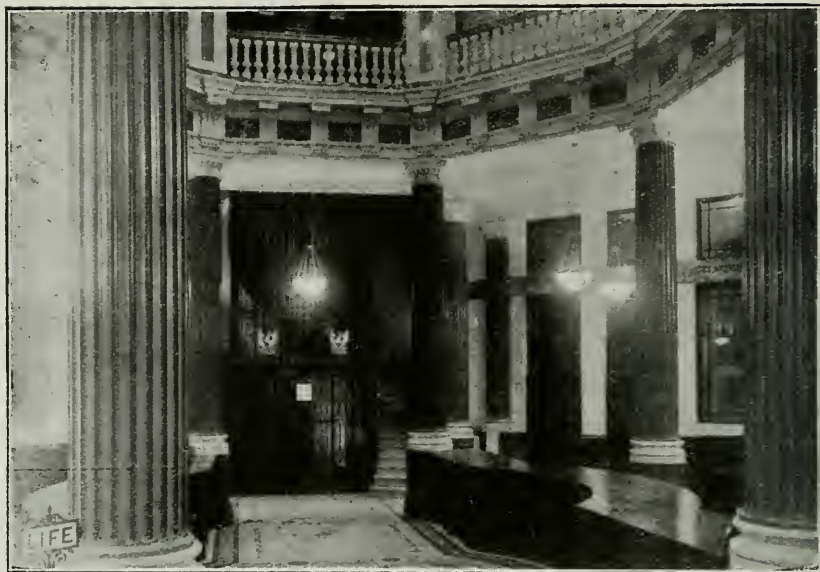
This is probably one of the largest semi-direct lighting installations in London, there being about 1,200 lamps of 20 to 100 watts each. The ground floor office occupies approximately 65 square feet and is lighted by 22—100 watt "half watt" lamps in diffusing glass reflectors, hung at a height of 14 feet. (See Figs. 2 and 3.) In addition to these lights there is a large central chandelier (shown in Fig. 1).



Lumina Bureau Photo.

FIG. 1.—Centre Chandelier.

This was specially designed to suit the decorative requirements of the office, besides assisting the illumination on the ground floor. Measurements show that the illumination of the counters is of the order of 3 to 4 foot-candles, the corresponding values on the desks under the galleries being 4—6 candles. The whole of the fittings are of handsome Georgian style and were specially designed for the building.



Lumina Bureau Photo.

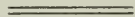


Lumina Bureau Photo.

FIGS. 2 & 3.—Views of the ground floor of the Phoenix Assurance Co. (King William Street, E.C.), illuminated by "Half-watt" lamps in diffusing glass bowls.

There has been, during recent years, a great deal of discussion as to whether general lighting of this kind is advisable in banks or offices, or whether local lamps for each worker are needed. The latter system, once universal, is being gradually replaced and there seems good ground for thinking that general illumination will do all that is necessary, providing the illumination is well distributed, and the filaments of lamps are screened by suitable globes or hemispheres. In the earlier installations of this class, before the more efficient incandescent lamps were introduced, preference for local lighting was, perhaps, due to the fact that the working illumination was not always sufficient for ledger work. In the present instance, however, the illumination provided seems ample.

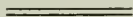
The coroner said the man had been sacrificed to the needs of the war in the same way as others had been sacrificed at the front.



HOODED LAMPS FOR STAIRCASE LIGHTING.

THE lighting of stairways is one of those simple problems which are often incompletely solved, merely because they do not receive enough attention. One not infrequently sees unnecessarily powerful lamps used for the purpose, and their utility is much restricted by lack of proper screening appliances. As a matter of fact, quite small miniature units often suffice for the purpose, provided the lamp is completely screened from persons using the stairs (especially those *descending*), and the illumination is distributed evenly along the flight of stairs. In the case of buildings used mainly by old and infirm people, who are particularly liable to trip, and cannot recover themselves easily if they do so, and in buildings constantly used for meetings of various kinds, good stair-lighting is particularly important. It should be made a special feature in hospitals, infirmaries, homes for incurables, &c.

An instance was afforded at a recent meeting attended by veterans of the American Civil War in a Chicago armoury. Through the thoughtfulness of those responsible for the gathering, a special hooded lamp was employed at the foot of a long flight of stairs, so that all the old soldiers reached the last step in safety.



ACCIDENTS DUE TO DIMINISHED STREET LIGHTING.

ANOTHER instance of a fatal accident ascribed to the diminished public lighting is described in the *Evening News* as follows:—

The peril of reduced street lighting owing to the war was emphasised at an inquest at East Ham to-day on Richard Matteson, of Green Street, Upton Park.

He rode out of Green Street on a cycle into the Romford Road, Forest Gate, and collided with a taxicab. He was killed on the spot. The scene of the accident was described as one of the most dangerous in the district.

The jury, in returning a verdict of accidental death, said it was due mainly to the reduced lighting. They exonerated the driver of the taxicab from blame. They regarded Matteson to a certain extent as a war victim.

BENJAMIN "HALF-WATT" ACCESSORIES.

WE are familiar with the data available on the spacing of reflectors of the E, I, and F type for ordinary tungsten lamps, and it is satisfactory to note that the range of fittings of this type available for half-watt lamps is rapidly growing.

The Benjamin Electric Ltd. have issued a useful pamphlet (List No. 506) in which a great variety of half-watt fittings are described. Some of these are of the

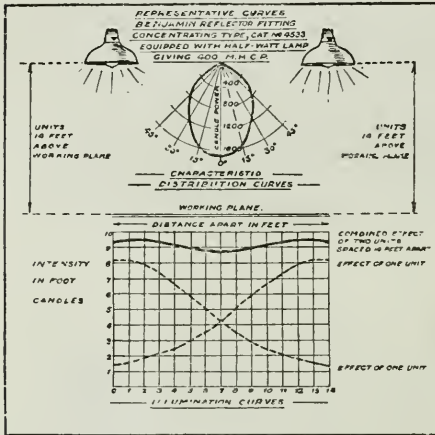
are given together with an illustration of the fitting, the whole being assembled conveniently on the same page. We reproduce a typical reflector and polar curve. Special holders have been designed to avoid excessive heating and some of the types are specially prepared with a view to being weatherproof.

It is interesting to note that semi-indirect fittings are listed for "half-watt" lamps up to 1000 watts, and there are also angle-type reflectors for special lighting.

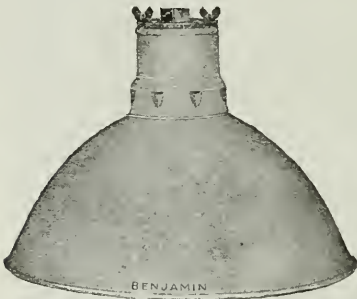
The booklet commences with some general notes on industrial lighting, definition of the chief units, and desirable values of illumination for various classes of work being quoted. An example is given of how the consumption necessary to produce a given illumination may be readily calculated. Finally there is a page devoted to Marbella reflectors, and a summary of miscellaneous accessories such as Goliath screw lampholders, brackets, ceiling plates, &c.

There is no doubt that the assembling of information of this kind is a great help in planning the lighting of factories, and by using well-known types of E, I, or F type fittings, for which the polar curves are known, the resulting illumination can now be determined beforehand with quite sufficient accuracy for practical purposes.

If we might make a suggestion for a future edition, we should like to see similar data provided for the semi-indirect fittings. No doubt in this case the illumination could not be predicted quite so readily owing to the important influence of reflection of light from the surroundings. But the approximate best spacing could be determined experimentally and, from experience of actual installations, the order of illumination for a given consumption of energy per square foot could be roughly indicated.



Characteristic photometric curve.



Half-watt Reflector Fitting (concentrating type, detachable flange pattern), for interior or exterior use with "One-watt" lamps up to 400 watts and "Half-watt" lamps up to 200 watts.

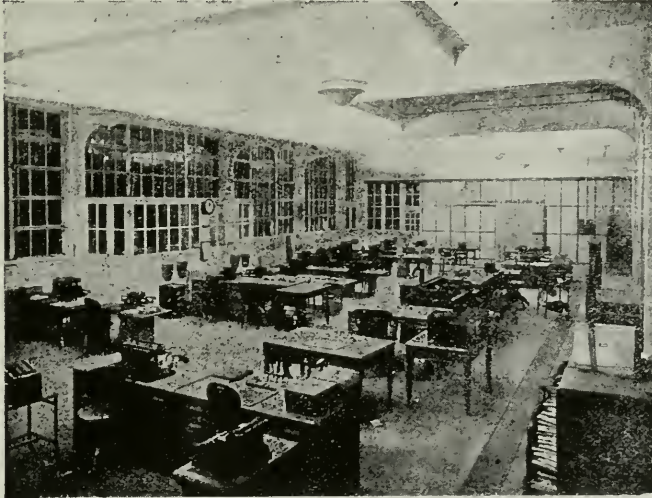
usual steel type, others are enamelled, and there are also cluster fittings. In each case the polar curve and the appropriate spacing rule for even illumination

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

INDIRECT OFFICE LIGHTING.



Typists' room in the offices of the Chiswick Polish Company, Limited, lighted by means of Mazda lamps in "Eye-rest" indirect lighting fittings.

THE accompanying illustration shows a good example of modern indirect office lighting, namely, the typists' rooms of the Chiswick Polish Co. The side of the office in the background is almost entirely of glass, the windows being carried up as high as possible so as to take full advantage of high-angle light. In the matter of artificial lighting arrangements have also been made to gain good diffusion of light. The room is illuminated by a number of moulded compo. "Eye-Rest" fittings, each containing five Mazda lamps, in an appropriate X-ray reflector.

For this illustration we are indebted to the British Thomson-Houston Co., Ltd. The lighting of desks occupied by typewriting machines is an interesting one. It is well known that when local lights are employed their position has to be adjusted with some care, and is apt to be upset by any alteration in the grouping of machines. In such cases there is therefore much to be said for a well-diffused general illumination, avoiding inconvenient shadows however the machines are situated.

REVIEW OF BOOK.

Physical Optics. By Professor R. W. Wood. (Macmillan & Co., London and New York, 1914; 705 pp., 399 illustrations.)

PROF. WOOD'S comprehensive volume carries the student a considerable distance further than do most treatises on Optics, and contains some of the very latest work on this subject.

The earlier chapters on The Nature of Light; its Propagation, Reflection and Refraction, follow more or less conventional lines, but are decidedly fuller and more advanced than is the case in most text-books, and contain some novel diagrams and methods of treatment. Interference, Diffraction, Polarised Light and Spectroscopy are treated in a quite up-to-date manner, while the concluding chapters break what will to most students be new ground. The discussion of Radiation is particularly interesting, although we personally would have liked to have seen a somewhat fuller account of the bearing of this subject on artificial light production. We notice a plate of one of Prof. Wood's celebrated landscape photographs by infra-red rays. Of considerable interest is the chapter on the transformation of absorbed radiation, which is also illustrated by special plates, and the discussion of the scattering effect of fine particles and the theory of "optical resonance," which is also a field of study Prof. Wood has made his own.

The chapter on magneto-optics contains a considerable amount of matter not readily found elsewhere, and we note that the author has been fortunate in receiving particulars of some of the very latest researches of Prof. Zeeman. In the preface to this new edition Prof. Wood suggests that some readers may consider that an unduly large space has been allotted to lines of experiment with which he has been intimately associated. We think that, on the contrary, the references to this special work render the book of special value and give it a distinctive character. We have already a number of excellent works on the fundamental principles of Optics to which Prof. Wood's book will form a useful supplement.

PERSONAL.

WE note that Mr. Malcolm Macfarlane, a member of the Illuminating Engineering Society, has now been granted a Commission in the Royal Engineers (1st London Division).

A NATIONAL GAS-LIGHTING WEEK IN THE UNITED STATES.

WE notice that an apparently very successful "gas-lighting" week was recently organised in the United States, displays being arranged in many cities. For example, the display at Jersey City included many tasteful model shop-window lighting exhibits, a feature being the number of semi-indirect lighting units. The attendance during the first week exceeded 4,000, and almost all the appliances exhibited were sold. As an educational campaign the display was also a marked success, visitors coming from most of the gas companies in the district and also from the Master Plumbers' Association of Hudson County.

A striking exhibit at Wilmington (Del.) was a window containing a complete model of a section of the proposed Du Pont Boulevard, the houses being shown to scale and miniature mantles on small posts and even small model motor-cars being shown. We observe also a series of excellent photographs showing the exhibits at Newark, some of the model interiors fully equipped with suitable "Christmas gifts," being particularly attractive.

A feature of the campaign was the prominent advertising of the National Gas-Lighting Week in the local papers.

Established
1885.



Established
1885.

By Appointment.

GENERAL

Accident Fire and Life
Assurance Corporation, Limited

Assets Exceed - £2,500,000.
Claims Paid Over £7,000,000.

SPECIAL FEATURES:

ACCIDENT INSURANCE

Liberal Benefits and Conditions.
Low Premiums.

FREE FIRE INSURANCE

EVERY SIXTH YEAR TO PRIVATE PROPERTY
OWNERS AND HOUSEHOLDERS.

THREE POPULAR POLICIES

Of Life Assurance, with Various Options

All Classes of Insurance Business Transacted

CHIEF OFFICES:

General Buildings, Perth, Scotland.
General Buildings, Aldwych, London.
General Manager - F. NORIE-MILLER, J.P.

NOTE.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

INDEX, December, 1915.

	PAGE
Editorial by L. GASTER	479
Illuminating Engineering Society—	
(Founded in London, 1909)	
Account of Meeting on Nov. 23rd	483
Progress during the Vacation	483
New Members	506
The Report of the Departmental Committee (Home Office) on Factory Lighting by L. GASTER	
485	
<i>Discussion:—Dr. R. T. GLAZEBROOK—Dr. RENE SAND—Dr. J. KERR—W. R. COOPER—A. CUNNINGTON—C. C. PATERSON—J. ECK—L. SOLOMON—E. T. SWINSON—G. CAMPBELL—F. W. GOODENOUGH—H. C. WHEAT—L. GASTER (in reply)</i>	
497	
Office Lighting, A Modern Example of	507
Topical and Industrial Section:—	
Benjamin "Half-Watt" Fittings	510
Indirect Office Lighting	511
Review of Book ("Physical Optics," by Prof. R. W. Wood)—A National Gas-lighting Week in the United States	512
Insurance Coupon	513
The Industries of Empire Fair—"Who's to Blame?"—"Light and Munition Work"—Recovery of Mantle Ash—British-made Mantles	514

COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

GENERAL

ACCIDENT FIRE AND LIFE

ASSURANCE CORPORATION, LTD.,

Chief Offices—

GENERAL BUILDINGS, PERTH, SCOTLAND.

GENERAL BUILDINGS, ALDWYCH, LONDON, W.C.

F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

THE INDUSTRIES OF THE EMPIRE FAIR.

We have received a prospectus of the coming Industries of Empire Fair, to take place in the Palace of Industry, Willesden Green, during March 6th-25th, 1917. It is to be hoped that the War will have terminated at least by that date, and if so the moment will be very opportune to encourage British trade. It is stated that the building in which the fair is to be held will occupy more than three times the space filled by any other exhibition building in London, and will thus be one of the largest of its kind in the world. As previously mentioned there is to be a special Heating, Lighting and Cooking Section at which we hope full justice will be done to illumination.

Those interested should communicate with the Administration Offices, Lincoln House, High Holborn, W.C.

"WHO'S TO BLAME?"

Under this title **Holophane Ltd.** issue an attractive little notice laying stress on the need for good industrial illumination and drawing attention to the flicker and inconvenient striations caused by lamps enclosed in wire guards and tin shades instead of properly designed reflectors. "Scientific Lighting," it is claimed, "is cheaper than "Rule of Thumb Lighting." A man cannot turn out first-class work with poor tools; neither can he do so with badly directed light. In the Holophane System of Industrial Lighting the light is properly distributed and such defects as the above are avoided.

The front page of the leaflet shows a picture of the employer and the workman discussing the matter.

"LIGHT AND MUNITION WORK."

A circular from the **General Electric Co., Ltd.**, likewise emphasises the value of properly designed reflectors to aid good lighting, and quotes the definition of adequate lighting contained in the recent Home Office Report. Evidence is quoted to the effect that imperfect lighting con-

ditions diminish the output and give rise to accidents, and reference is again made to the superiority of scientific methods to procedure according to "Rule of Thumb."

RECOVERY OF MANTLE ASH.

We notice in a recent issue of the *Journal of Gaslighting* an account of experiments of Herr J. van Rossum du Chattel, Director of the Amsterdam Gas Works, on the recovery of rare earth materials from spoiled or used mantles.

In Amsterdam boxes are provided (each holding 25 kilos.) for the collection of used mantles by workmen engaged in the attending to burners. It is stated that from 1000 used mantles enough material is obtained for the impregnation of 270 new ones. It may, however, be necessary to add a certain amount of cerium nitrate to the solution thus obtained before it is fit for use.

BRITISH-MADE MANTLES.

The same issue of the *Journal of Gaslighting* contains a letter from Mr. F. D. Marshall on imported mantles. Mr. Marshall gives an account of a visit to the Deutsche Gasglühlicht Aktiengesellschaft before the war, in the course of which he was shown a number of German factories. It is common knowledge that in those days this country was dependent to a very great extent on material and even apparatus imported from Germany, and it is to be hoped that a different state of things will prevail after the war is over.

It is evident, however, that an industry of this kind cannot be built up without much patience and energy. No one can help recognising the immense labour and energy which has been bestowed on this problem on the Continent; yet if we in this country bring similar efforts to bear there is no reason to fear that we cannot do as well. Happily in many directions considerable progress has already been made since the outbreak of war.

AUTHORS' INDEX.

A	PAGE	C	PAGE
Allen (E.) on Practical Rating of Electric Incandescent Lamps, The (Discussion)	182	Campbell (G.) on First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion) ..	502
Ashe (Sydney W.) on Accidents, The Application of Educational Methods to the Reduction of ..	349	Cash (F. T.) on Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations (Discussion)	136
Ayrton (Mrs. H.) on Searchlights, their Scientific Development and Practical Applications (Discussion)	71	Chalmers (S. D.) on Searchlights, their Scientific Development and Practical Applications (Discussion)	70, 218
Conditions Determining the Candle-Power and Steadiness of Large Current Arcs for Searchlights. Some Notes on the	78	Clark (J. G.) on The Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations (Discussion)	133
B		Practical Rating for Electric Incandescent Lamps (Discussion)	178
Bailey (F.) on Illuminating Engineering in War Time (Discussion)	22	Visibility; Some Practical Aspects of the Question (Discussion)	224
The Development and Design of Lighting Fixtures in relation to Architecture and Interior Decorations (Discussion)	135	Lighting of Rifle Ranges (Discussion)	272
Lighting of Rifle Ranges (Discussion)	271	Commandant, Depot R.M., Deal, on Lighting of Rifle Ranges (Discussion)	277
Bassett (W. J.) on Lighting of Rifle Ranges (Discussion)	269	Commandant, Royal School of Musketry, Hythe, on Lighting of Rifle Ranges (Discussion)	270
Batstone (T. C.) on Electric Light Fitting (Review)	320	Cooper (W. R.) on First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion)	497
Blok (A.) on Lighting of Rifle Ranges (Discussion)	256	Coram (T. G.) on Lighting of Rifle Ranges (Discussion)	272
Blondel (Prof. A.) on Searchlights, A Method for Determining the Range of	85, 153	Crowley (J. F.) on Searchlights; Some Remarks on the more Electrical Systems of Operation	159
Brazil (H.) on Lighting of Rifle Ranges	268	Annual General Meeting	244
Broadberry (A. E.) on Factory Lighting by High Pressure Gas	199	Cunnington (A.) on Illuminating Engineering in War Time (Discussion)	24
Burt (C. H.) on The Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations	130	First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion)	498
Bussell (R. C.) on Illuminating Engineering in War Time (Discussion)	25		
Practical Rating of Electric Incandescent Lamps (Discussion)	179		
Butterfield (W. J. A.) on Practical Rating of Electric Incandescent Lamps (Discussion)	185		

D	PAGE
Darch (John) on The Principles of Design in Lighting Fixtures	120
Visibility; Some Practical Aspects on the Subject (Discussion)	223
Dow (J. S.) on Searchlights, their Scientific Development and Practical Applications (Discussion)	72, 127
Practical Rating of Electric Incandescent Lamps (Discussion)	179
Visibility; Some Practical Aspects of the Question (Discussion)	222
Lighting of Rifle Ranges (Discussion)	278
War, Visibility Problems in ..	302
Dudding (B. P.) on Visibility; Notes on Some Practical Aspects of the Question	210

E

Eck (J.) on Searchlights; their Scientific Development and Practical Applications (Discussion)	59
Practical Illumination (Review)	190
First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion)	501
Edridge-Green (Dr.) on Visibility; Some Practical Aspects of the Question (Discussion)	220
Ettles (Dr. W.) on Visibility; Some Practical Aspects of the Subject (Discussion) ..	216
Lighting of Rifle Ranges (Discussion)	276
Evans (William A. D.) on Moving Picture Studios, The Artificial Lighting of	284

F

Fletcher (J. Y.) on Practical Rating of Electric Incandescent Lamps (Discussion)	176
Foulds (M.) on Practical Rating of Electric Incandescent Lamps (Discussion)	178
Annual General Meeting ..	244
Freak, on Lighting of Rifle Ranges (Discussion)	269

G

Galsworthy (Montague H.) on Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations	140
--	-----

	PAGE
Gaitskell-Burr (Col.) on Lighting of Rifle Ranges (Discussion) ..	269
Gaster (Leon), Editorials, 1, 41, 97, 149, 193, 239, 293, 331, 365, 405, 441, ..	479
War Time, Illuminating Engineering in	13, 25
Electric Incandescent Lamps, Practical Rating of (Discussion)	179
Annual General Meeting ..	244
First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops, Some Notes on the	485, 504
Gilbert (Walter) on Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations, The ..	139
Glazebrook (Dr. R. T.) on First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion)	497
Goodenough (F. W.) on Practical Rating of Electric Incandescent Lamps (Discussion) ..	181
Annual General Meeting ..	243
Sale of Gas in the United Kingdom, Present Practice in the First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion)	502
Gregory (Prof. R. A.) on Science in the Daily Press	203

H

Harrison Haydn (T.) on Practical Rating of Electric Incandescent Lamps (Discussion) ..	182
Visibility; Some Practical Aspects of the Question (Discussion)	220
Hastings (Chas. W.) on Gas Engineering—Gas Manufacture: A Review of the Institution of Gas Engineers (Review)	357
Hawkins (F. J.) on Practical Rating of Electric Incandescent Lamps (Discussion)	184
Helps (W. D.) on The Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations (Discussion) ..	127
Herbert (G.) on Lighting of Rifle Ranges (Discussion)	270
Hovestadt (Dr. H.) on Jena Glass (Review)	476

	PAGE		PAGE
Howling (W. H.) on Development and Design of Lighting Fixtures in Relation to Architecture and Interior Design (Discussion) ..	139	Morley (W. M.) on Searchlights; their Scientific Development and Practical Applications (Discussion) ..	61
J		Morris (Prof. J. T.) on Practical Rating of Electric Incandescent Lamps, The (Discussion) ..	176
Johnson (J. H.) on Searchlights, Their Scientific Development and Practical Applications (Discussion) ..	72	Mullard (S. R.) on Practical Rating of Electric Incandescent Lamps (Discussion) ..	178
Electrical Engineers Diary for 1915 (Review) ..	190	P	
K		Parsons (J. Herbert) on Visibility; Some Practical Aspects of the Question ..	225
Keith (G.) on Practical Rating of Electric Incandescent Lamps ..	183	An Introduction to the Study of Colour Vision (Review) ..	319
Kerr (Dr. James) on First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion) ..	497	Pearce (L. R. B.) on Searchlights; Their Scientific Development and Practical Applications (Discussion) ..	69
Kitson (A.) on Searchlights, Their Scientific Development and Practical Applications (Communicated) ..	76	Paterson (C. C.) on Searchlights; Their Scientific Development and Practical Applications (Discussion) ..	71
L		Practical Rating of Electric Incandescent Lamps (Discussion) ..	175
Lange (K. R.) on Bye-Products of Coal Gas Manufacture (Review) ..	320	Visibility; Notes on Some Practical Aspects of the Question ..	210
Ledger (P. G.) on Searchlights; Some Notes on Their Scientific Development and Practical Application ..	53, 71	First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion) ..	500
Le Marechal (M.) on Practical Rating of Electric Incandescent Lamps (Discussion) ..	178	Penn (A. E.) on Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations, The (Discussion) ..	134
Liberty (W. J.) on Illuminating Engineering in War Time (Discussion) ..	22	Philip (A. J.) on Library Lighting, Some Notes on ..	465
Lomas (H. M.) on Picture Play Photography (Review) ..	357	Pickard (T. B.) on Lighting of Rifle Ranges (Discussion) ..	272
Luckiesh (M.) on Safeguarding the Eyesight of Children ..	297	Pinkney (W. F. T.) on The Development and Design of Lighting Fixtures in Relation to Architecture (Discussion) ..	138
Lundberg (A. P.) on Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations (Discussion) ..	142	R	
Lyon (A.) on Searchlights; their Scientific Development and Practical Applications (Discussion) ..	61	Ritchie (T. E.) on Illuminating Engineering in War Time (Discussion) ..	23
M		Searchlights; Their Scientific Development and Practical Applications (Discussion) ..	63
Macintyre (J.) on Illuminating Engineering in War Time (Discussion) ..	24	Practical Rating of Electric Incandescent Lamps (Discussion) ..	177
Practical Rating of Electric Incandescent Lamps (Discussion) ..	176	Ryan (W. D'A.) on Illumination of the Panama-Pacific International Exhibition ..	305
Marks (P. L.) on Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations, The (Discussion) ..	134		

	S	PAGE
Sand (Dr. René) on First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion)	497	
Schamasch (A.) on Lighting of Rifle Ranges (Discussion)	267	
Smith (Harold) on Searchlights; Their Scientific Development and Practical Applications (Discussion)	69	
Solomon (Lewis) on First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion)	501	
Staniforth (H.) on Practical Rating of Electric Incandescent Lamps	184	
Stroud (E.) on Practical Rating of Electric Incandescent Lamps (Discussion)	178	
Swinson (E. T.) on First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion)	502	
T		
Thompson (Prof. Silvanus P.) on Practical Rating of Electric Incandescent Lamps	180	
Thorpe (F.) on Some Notes on the Development and Design of Lighting Fixtures in relation to Architecture, Interior Decoration, and Illumination	103, 144	
Tilley (F. S.) on Illuminating Engineering in War Time	25	
Practical Rating of Electric Incandescent Lamps (Discussion)	179	
Trotter (A. P.) on Projectors, Practical and Theoretical Notes on	82	
The Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations (Discussion)	124	
Practical Rating of Electric Incandescent Lamps (Discussion)	181	
Visibility; Some Practical Aspects of the Question (Discussion)	216	
Annual General Meeting	243	
Lighting of Rifle Ranges; Some Points in connection with the	251, 280	

	PAGE
Waldram (P. J.) on The Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations (Discussion)	128
Visibility; Some Practical Aspects of the Question (Discussion)	223
Lighting of Rifle Ranges (Discussion)	268
Walsh (J. W. T.) on Illuminating Engineering in War Time (Discussion)	21
Practical Rating of Electric Incandescent Lamps (Discussion)	183
Warren (E. P.) on The Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations (Discussion)	125
Watson (Dr. W.) on Visibility; Some Practical Aspects of the Question (Discussion)	221
Webber (W. H. Y.) on Gas Supply in Principle and Practice (Review)	190
West (F.) on Lighting of Rifle Ranges (Discussion)	278
Wheat (H. C.) on First Report of the Departmental Home Office Committee on Lighting in Factories and Workshops (Discussion)	503
Willcox (F. W.) on Illuminating Engineering in War Time (Discussion)	25
Shoplighting in War Time (Corres.)	28, 358
Searchlights; Their Scientific Development and Practical Applications	66
Development and Design of Lighting Fixtures, in Relation to Architecture and Interior Decorations (Discussion)	142
Practical Rating of Electric Incandescent Lamps, The	163
Do. do.	180
Wilkinson (H. T.) on Development and Design of Lighting Fixtures in Relation to Architecture and Interior Decorations, The (Discussion)	140
Wood (Prof. R. W.) on "Physical Optics" (Review)	512
Wordingham (C. H.) on Rating and Marking of Lamps, The (Discussion)	174

SUBJECT INDEX.

A	PAGE	P	PAGE
Accidents, The Application of Educational Methods to the Reduction of, by S. W. Ashe ..	349	Diminished Illumination, and Accidents in the Streets ..	300 509,
Acetylene Signalling Lamp ..	94	Diminished Public Lighting, Safety Precautions in View of the ..	301
Anti-Aircraft Work, Searchlights for (Top. and Indus. Section) ..	91	Drawing Room, Combined Central and Bracket Lighting in a ..	314
Arc under High Pressure, The ..	81	Drawing Room, Semi-Indirect Lighting in a ..	428
Architecture, Interior Decoration and Illumination, Fixture Design in Relation to (Editorial) ..	97	Dyer's Hall, The Lighting of the ..	10
Artificial Digestion by Ultra-Violet Rays	315		
		E	
B		Ediswan Items (Top. and Indust. Section) 33, 38, 94, 146, 187, 234, 321, 326, 360, 434, 475	
Benjamin Specialities (Topical and Industrial Section) ..	32, 360, 510	Editorials, by L. Gaster 1, 41, 97, 149, 193, 239, 293, 331, 365, 405, 441, 479	
Blacksmith's Shop, Practical Lighting in a	390	Electric Incandescent Lamp during 35 years, The Development of the	456
Blanchard Lamps for Field Hospitals (Top. and Indus. Section) ..	289	Electrodes for an Improved Arc Lamp, A New Type of ..	304
Bleriot "no glare" Lamps (Top. and Industrial Section) ..	359	Empire Fair, The	356
British Gas Industries, Society of ..	326	Engineering Workshop, High Pressure Gas Lighting in (Top. and Indust. Section)	396
C		Eyesight of School Children, Safeguarding the, by M. Luckiesh ..	297
Ceiling Fitting, A Novel	432		
Cinematograph Studios and Theatres, Problems in the Lighting of (Editorial)	296	F	
Cinematograph Work, Some Notes on the Use of Light in ..	310	Factories and Workshops : The First Report of the Departmental Committee on the Lighting of (Editorial)	365
Coal Gas, Use of, for Industrial Purposes	192	Memorandum	369
Code of Lighting for Factories, Mills and other work places in the United States, A Suggested ..	414	Abstract	371
	441, 451	Notes on Evidence	420
Collective Advertising (Editorial) ..	152	Some Notes on, by L. Gaster ..	485
Colour and Heat	316	Factory Lighting, Contracts for ..	197
Coloured Light and the Modern Composer	316	by High Pressure Gas, by A. E. Broadberry	199
Colour, A New Method of Comparing Sources of Light which differ in ..	393	by Gas, Some Examples	329
CORRESPONDENCE :—		by Mercury Vapour Lamps ..	344
Conditions in Paris in War Time ..	27	Overhead System	343
Shop Lighting in War Time	28	Finsbury Park Empire, Lighting of ..	327
Wanted—A Name	236	Firefly and Other Luminous Organisms, The, by A. F. McDermott ..	393
Shop Lighting in War Time	358	Fittings, The Beutell System of ..	148
Diminished Street Lighting and Motor Traffic	464	Fixtures, Historical Development in Relation to Architecture, Interior Decoration and Illumination by F. Thorpe	103
D		Flicker Photometer, A New Form of, by H. F. Kingsbury ..	462
Daylight Sign, A	318		
Deliberation, then Organisation (Editorial)	331		

G	PAGE
Gas and Munitions of War ..	364
Glasgow Smoke Abatement Exhibition	328
Glassware to give Sunlight Colour Value with Incandescent Electric Lamps (Top. and Indust. Section)	189
Glassware, Rise in Price of ..	326
Glass Works, Ediswan, for Electric Lamps	434
Grading and Marking of Lamps, The (Editorial)	149

H	PAGE
Half-Watt Lamps 140, 230, 235, 290, 326, 360, 395	96
Haileybury College, Gas Lighting at	
Heating, Lighting and Cooking Exhibition	438
High Pressure Gas Lighting, The Keith System of	233
Holophane "Ouvoir" in Paris, The	394
Holophane Glassware, Lighting, Installations, &c. 36, 94, 235, 360, 398, 436, 473, 514	514
Hygiene and Sanitation, Lectures on	354

I	PAGE
Indirect Office Lighting (Top. and Indust. Section)	511
Industries of the Empire Fair, The Illuminating Engineering—	514
Lectures on	90
Short Notes on .. 227, 315, 355, 391	
in War Time (Discussion)	20
in Germany	460
in Australia	461
A Year's Progress in (continued from p. 552 in Vol. VII.)	5, 45
Progress in	409, 445

Illuminating Engineering Society— (Founded in London 1909).	
Accounts of Meetings 11, 51, 101, 161, 209, 243	
New Members .. 12, 52, 101, 161, 209, 243, 506	
Proceedings at Meetings:—	
Illuminating Engineering in War Time	13
Searchlights, their Scientific Development and Practical Application	53
The Historical Development of Lighting Fixtures in Relation to Architecture, Interior Decoration and Illumination	103
The Practical Rating and Marking of Electric Lamps	163
Visibility; its Practical Aspects	209
The Lighting of Rifle Ranges ..	251
Annual General Meeting ..	243
Report of the Council	245

	PAGE
Illuminating Engineering Society (U.S.A.)	318, 457
Annual Convention	353
(Editorial)	443
Illuminating Glassware ; a National Industry (Editorial)	100
Illumination, Fatigue in Relation to (Editorial)	481
Illumination of Signs and Building Exteriors by Projectors	315
Illuminated Sign, A New Type of	400
Illumination in the United States, Popular Lectures on	249
Industrial Lighting, A New Series of Reflectors for (Topical and Industrial Section)	145
Industrial Lighting, A New Reflector for	235
International Gas Congress in San Francisco, The	402

L	PAGE
Library Lighting, Some Notes on. by A. J. Phillip	465
Light and the Human Machine (Editorial)	333, 335
and Superstition	392
and Munition Work	514
on Coloured Fabrics, Effect of ..	292
Economy in the Use of	402
Lighting Installations, How to Plan (Top. and Indust. Section) ..	188
Chart for Planning (Top. and Indust. Section)	189
Lighting Booklet, The (Top. and Indust. Section)	475
Lighting of Rifle Ranges (Editorial)	239
Queries on	250
Some Points in Connection with (Discussion)	251, 256
Lighting and Ventilation	292
Lighting Restrictions and Coal Deliveries	459
Lighting Regulations in War Time (Editorial)	28, 423, 405
London's Lighting during the War, Notes on	463
Low-pressure Gas Lighting in a Body-building Shop	192

M	PAGE
Machine to Register Fatigue	186
Machinery painted White	356
Mantle Ash, The Recovery of	514
Mantles, British made	514
"Matching the Snow"	317
Mazda Lamps and Fittings 30, 145, 230, 327, 360, 440, 474, 511	
Mercury Vapour Lamps, Industrial Lighting by	344

	PAGE
Metal Work Plants, Electric Lighting of, by A. L. Powell and R. E. Harrington	198
Mitre Tavern, Ye olde, Lighting of	322
Miniature Rifle Ranges, Some Examples of the Lighting of	257
Modern Interior Shoplighting, Some Examples of	34
Modern Schoolroom, Blackboard Lighting in a	238
Modern Factory Lighting by Gas, Some Examples of	339
Modern Office Lighting (Editorial)	482
Modern Office Lighting, An Example of	507
Moore Light in Spain, The	324
Motor Car Races at Night	424
Moving Picture Studios, Artificial Lighting of	284
Moving Picture Equipment, A Unique, by W. A. D. Evans	461
Munition Workers, Health of, and Industrial Fatigue (Editorial)	479

N

National Welfare, Co-operation for the (Editorial)	242
National Physical Laboratory (Top. and Indust. Section)	362
National Gas-Lighting Week in the United States, A	512
National Illumination Commission	450
Nonpareil Inverted Incandescent Gas Sunburner (Top. and Indust. Section)	187

O

Obituary Notices:—	
Allen, Edward	348
Byng, H. G.	290
Gooch, F. H.	476
Lewes, Prof. Vivian	472
Louis, Prof. D. A.	283
Maurice, F. G.	236
Old Models and New Methods (Top. and Indust. Section)	30
Operation, Failure of Light during an	392
Operating Theatre, The Importance of Background in the	462
Osram Lamps, and Fittings therefor	37,
38, 146, 187, 229, 326, 359, 401, 436, 473	
Outside Lighting, Holophane Glass-ware for	36
Overhead Shoplighting	343
Oxy-acetylene Searchlight, The	84

P

Panama-Pacific Exhibition, Gas-lighting at the	304
--	-----

	PAGE
Panama-Pacific International Exhibition, Illumination of the, by W. D'A. Ryan	305
Panama-Pacific Exhibition, The Lighting of (Editorial)	334
Paper and other Materials, Testing the Gloss of	425
Paris, The Lights of	355
Past Year, Progress of (Editorial)	1
Personal Notes 148, 290, 328, 362, 476, 512	
Petromax Lamp, The	234
Photographic Value of Illuminants	347
Photometric Tests of Street Lamps in a Lawsuit in Philadelphia	316
Polish Campaign, Searchlights in	186
Podmore Specialities	436
Porch Lighting	473
Portable Acetylene Lamp, A Compact Type of	404
Postal Rates, The New (Editorial)	408
Practical and Theoretical Notes on Projectors, by A. P. Trotter	82

R

Railway Lighting, Special Problems in	345
Railway Station Lighting (Top. and Indust. Section)	360
Do. with Half-Watt Lamps	395
Railway Termini, Signs at	318
Railway Carriage Lighting	330
Rating and Marking of Lamps, and the Best Methods of Specifying their Illuminating Value, The	161
Do. Queries on	162
Do. Discussion	174
Reed-wave Lighting Fixtures	228
REVIEW OF BOOKS:—	
Johnson, J. H., Electrical Engineers Diary	190
Webber, W. H. Y., Gas Supply in Principle and Practice	190
Eck, Justus, Practical Illumination	190
J. Herbert Parsons, An Introduction to the Study of Colour Vision	319
K. R. Lange, Bye-Products of Coal Gas Manufacture	320
S. C. Batstone, Electric Light Fitting	320
H. M. Lomas, Picture Play Photography	357
Chas. W. Hastings, Gas Engineering and Gas Manufacture; A Review of the Institution of Gas Engineers	357
Dr. H. Hovestadt, Jena Glass and its Scientific and Industrial Applications	476
Prof. R. W. Wood, Physical Optics	512

S	PAGE		PAGE
Sale of Gas in United Kingdom, Present Practice in the, by F. W. Goodenough	458	Thoria and Ceria in England, The Manufacture of	32
School Lighting, A Committee on, in the United States	39	Topical and Industrial Section 29, 91, 145, 187, 229, 289, 321, 359, 391, 433, 473, 511	
Schoolroom, Daylight Illumination in the	457	Trade Journalists and the Board of Trade	207
Science and Invention, The Organ- isation of (Editorial)	293	Traffic Regulators, Luminous Gloves for	356
Science in the Daily Press	203	Traffic in America, Aids to	424
Do. (Editorial)	196	Travancore, The Monazite Sands of (Top. and Indust. Section) ..	396
Searchlights; their Scientific Devel- opment and Practical Applica- tion (Editorial)	41	Tungsten, The Melting Point of ..	391
Do. by P. A. Ledger	51		
Searchlights, A Method of Deter- mining the Range of, by Prof. A. Blondel	85, 153	U	
Practical and Theoretical Notes on, by A. P. Trotter	82	Ultra-Violet Light on the Eye. The Effect	303
Conditions affecting the Candle- power and Steadiness of, by Mrs. Hertha Ayrton	78		
Remarks on the usual Electrical Systems of Operation, by J. F. Crowley	159	V	
Selfridge's, Half-Watt Lighting at Shoplighting, Design of (Top. and Indust. Section)	30	Ventilation, The Change in Ideals for	438
Do. Examples of	34	Verity's Fixtures	30, 92
Showrooms of the Tottenham and District Light, Heat and Power Co., A Section of the	232	Visibility; Some Notes on Some Practical Aspects of the Ques- tion, by C. C. Paterson and B. P. Dudding	210
Show Windows, X-ray Reflectors for	31	(Discussion)	216
Shop Window Lighting, Reflectors for (Top. and Indust. Section)	31, 32, 229	Queries on	208
Siemens Announcements, Installa- tions, &c. 34, 146, 148, 187, 321, 326, 360, 391, 473	473	(Editorial)	195
Soldiers and Sailors, Our Blinded ..	329		
Staircase Lighting, Hooded Lamps for	509	W	
Statues and Monuments, Lighting of	227	War, Acetylene and the	37
Street Lighting, Statistics on ..	186	War, Visibility Problems in the ..	302
Street Lighting and Motor Traffic, Diminished (Correspondence) ..	464	War Time, Shoplighting in (Corres- pondence)	28, 358
Street Lighting in Chicago	391	Lighting in	28
Submarine Photography by Aid of a Quartz Mercury Lamp	317	Street Lighting in (Editorial) ..	44
		Conditions in Paris in (Corres- pondence)	27
T		Factory Lighting in (Editorial) ..	193
Tailory and Hosiery Shop, A Well- Lighted (Top. and Indust. Section)	360	Illuminating Engineering in (Dis- cussion)	13
Technical Instruction, Illuminating Engineering as a Branch of ..	430	Lighting of a Church in	478
		West African House, Kingsway, The Lighting of (Top. and Indust. Section)	474
		Whitewashed Kerbs	228
		Woodworking Shop, Gas-Lighting in a	430
		Workshop, Incandescent Oil Light- ing in a	433
		Z	
		"Zenda" High Pressure Petroleum Lamp	37

AGE

111
A.
Pract
on,
Condit
powe
Mrs
Rema
Sys
Crov
Selfridge's
Shoplighti
Indust
Do. Exam
Showrooms
District L
Co., A Sec
Show Windows,
Shop Window I
for (Top. an

Siemens Annou
tions, &c.

Soldiers and Sail
Staircase Lighti
for
Statues and Mon
Street Lighting,
Street Lighting a
Diminished (C
Street Lighting in
Submarine Photog
Quartz Mercu

Tailory and Hosiery S
Lighted (Top. :
Section) ..
Technical Instruction,
Engineering as a B

TP
700
L54
v. 8

Light and lighting

~~Physical &~~
~~Applied Sci~~
~~Serials~~

Engineering

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGINE STORAGE

